POPULATION COVERAGE OF MATERNAL, NEWBORN AND CHILD HEALTH INTERVENTIONS:
THE IMPACT OF DONOR FINANCING, COVERAGE CHANGE METRICS AND PREDICTORS OF MATERNAL HEALTH SERVICE UTILIZATION.

By
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Abstract

Background

Donor financing in conjunction with national policies works through the existing health system to impact the uptake of MNCH interventions. However within countries, other key factors such as individual and household behaviors, the political economy, and the macroeconomic environment also influence the uptake of interventions. Demonstrating the relationship between increased financing and increased coverage can provide a platform for policymakers and other stakeholders to refine and appropriately target their health programs.

Methods

This complex relationship between financing and coverage was analyzed on a global level among multiple countries: 1) A multi-country analysis examining the impact of official development assistance on the change in coverage levels of MNCH interventions; 2) To further contextualize the results of the multi-country analysis, a systematic review was performed to identify the different metrics used in computing coverage change; and 3) Individual-level factors related to utilization of maternal health services was examined among women of varying socioeconomic status in Nigeria.

Results

The multi-country analysis examining the impact of official development assistance (ODA) on coverage levels of MNCH interventions positive associations. The systematic review found that the method of computing change is important in coverage change

estimates; and this can impact findings and future research directions. Furthermore, the trend of coverage rates within a country and the baseline rate is also important. Lastly, predictors of maternal health service utilization among Nigerian women were maternal education and employment.

Conclusion

This analysis has shown that ODA to maternal and child health can be effective in increasing the coverage rates of MNCH interventions. These results are important and present a preliminary attempt to understand this complex relationship between financing and the uptake of health interventions. In addition, the coverage change metrics utilized are important can have a significant impact on the results of coverage change analyses.

Lastly, in our analyses that examined individual level factors associated with maternal health service utilization, maternal education and employment are shown to be important factors associated with utilization regardless of socioeconomic status. Understanding the dynamics between individual level predictors and the uptake of interventions is important to ensure that those in need are appropriately targeted for health interventions.

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"He who is carried on another's back does not appreciate how far off the town is".

African Proverb

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I would like to dedicate to this dissertation to my daughter, Jayamma Chidera Nwaohiri, We love you, you are never forgotten. Till we meet again.

We would have lost heart, unless we had believed that we would see the goodness of the LORD in the land of the living.

Psalm 27:13.

ALL THANKS BE TO GOD WHO ALWAYS CAUSES US TO TRIUMPH!

Contents

Introduction

Official Development Assistance

Official Development Assistance (ODA) is defined as resource flows in the form of concessional grants or soft loans to countries that are provided by official governmental agencies with the primary objective of promoting the welfare and economic development of developing countries.[1] Twenty-three member countries of the Organisation for Economic Co-operation and Development (OECD), in addition to the European commission, provide these resources.[1] ODA provides resources that promote development across various sectors including health, social and economic growth, governance, conflict prevention and emergency assistance.[2] The largest recipient of ODA is the sub-Saharan African (SSA) region. However, due to the population density, average ODA per poor person in SSA is less than other regions. For instance, during the period 2009-2011, average ODA per poor person was US$97 in SSA compared to US$601 in North Africa; India and China had ODA per poor person averages between US$2 and US$6, the lowest of all countries.[2]

Overall, 12% of all ODA disbursements are for health [2] and are categorized as either aid to health (which accounts for general and basic health services) or population policies/programmes and reproductive health including HIV/AIDS.[3] General health covers health policy and management, medical education/training, research and services. Basic health includes immunizations, maternal and infant nutrition programs, infectious disease, malaria and tuberculosis control. Population policies/programmes and

reproductive health covers population policy, family planning, and STI & HIV/AIDS prevention & control.[3]

ODA for Health & The Millennium Development Goals

As part of the Millennium Summit in 2000, world governments agreed upon a set of targets that were aimed at reducing extreme poverty and inequality worldwide.[4] These targets, referred to as the "Millennium Development Goals" (MDGs), cover eight distinct categories and are accompanied by specific targets and indicators for measuring progress achieved between 1990 and 2015.[5] Out of the 8 MDGs, three goals are directly focused on health: MDG 4 - to reduce under-five mortality rate by two thirds between 1990 and 2015; MDG 5- to reduce maternal mortality ratio by three quarters between 1990 and 2015; and MDG 6- to combat HIV/AIDS, malaria and other diseases.[5] The majority of ODA commitments are targeted towards MDG 6, with 58% of commitments during 2009-10 going towards the fight against HIV/AIDS, malaria and other diseases.[6]

Since 2000, ODA for health has been on the rise. There was a 768% increase in ODA for health between 2000 and 2010 [6], although the rate of increase slowed over time.[7] This increase is due in part to the Millennium Development Goals (MDGs) [5], of which ODA provides a portion of the MDG financing alongside other development resources such as government expenditures on health, philanthropic organizations, innovative financing.[8] Despite the increase in financing, some sub-Saharan African countries are still lagging behind other countries in their progress towards achieving the MDGs.[9] To

achieve the MDGs, countries will need development assistance in addition to the appropriate targeting of resources to activities that will have the largest impact on the MDGs as well as developing strong policies and health systems.[10]

MDGs 4 & 5: Child & Maternal Mortality

Child mortality is an indicator that is used to monitor both child health and overall development in countries and is defined as the probability of a child dying between birth and the age of five years, expressed as a rate per 1000 live births.[11] The maternal mortality ratio is an indicator of the general health of a population and demonstrates the ability of women to obtain maternal and other health services; it is defined as the number of maternal deaths per 100,000 live births.[12]

Globally, child mortality has fallen from 12 million deaths in 1990 to 6.9 million deaths in 2011; this represents a 41% decline in the under-five mortality rate from 87 to 51 deaths per 1,000 live births between 1990 and 2011.[11] As of 2011, sub-Saharan Africa remains the only region with high child mortality, followed by Southern Asia, Oceania and Central Asia with moderate levels of child mortality; all other world regions have low levels of child mortality.[13] Despite the global gains in child mortality, over the same time period sub-Saharan Africa experienced only a 10% decrease, from 3.9 million child deaths in 1990 to 3.5 million child deaths in 2011. Consequently, the proportion of global child deaths contributed by the sub-Saharan Africa increased from 33% to 49%.[14] India (24%) and Nigeria (11%) are the two largest contributors to the child mortality rate, accounting for 35% of all under-five deaths.

Maternal mortality rates have also fallen world-wide, with about a 50% reduction from 1990 to 2010.[15] The sub-Saharan African region has the highest maternal mortality ratio, followed by the South Asian region; together they account for 85% of maternal deaths worldwide.[15] Again, India (19%) and Nigeria (14%) are the two largest contributors to maternal deaths, accounting for 33% of all maternal deaths worldwide.[15] Despite the current reduction in child and maternal mortality rates, accelerated progress is still needed to reach MDG 5, especially in the sub-Saharan Africa and South Asia regions that account for the majority of deaths.

Progress Indicators for MDGs 4 and 5

The Commission on Information and Accountability in Maternal, Newborn and Child Health defined eight core coverage indicators to monitor progress towards MDGs 4 and 5.[16] These indicators include the (1) met need for contraception, (2) antenatal care coverage, (3) antiretroviral prophylaxis to prevent mother to child transmission of HIV, (4) skilled attendant at delivery; (5) postnatal care for mothers and babies; (6) exclusive breastfeeding; (7) three doses of diphtheria, pertussis and tetanus (DPT3) vaccine; and (8) antibiotic treatment for pneumonia.[16]

In 2005, a collaboration named "Countdown to 2015" was established to track progress in the 75 countries that contribute 95% of maternal and child deaths worldwide.[17] Data from 73 countries with high burdens of maternal and/ or child mortality revealed that for these indicators, the median coverage across all countries is quite low for most of the eight core coverage indicators. The median overall coverage for 7 out of the 8 core

indicators is less than 60%, with the remaining indicator, DPT3, having a median coverage of 85%.[18] However, there is a wide range of coverage rates at the country level. For instance, the median coverage for skilled birth attendants is 57%, with a range of 18% to 100%.[18] There are also regional differences in coverage rates. For example, the coverage rate for antibiotic treatment of childhood pneumonia is as high as 62% in the Middle East and North Africa region, and as low as 18% in South Asia. The coverage rate for oral rehydration therapy is highest in East Asia and the Pacific, with a median rate of 41%, compared to a low of 30% in both the sub-Saharan Africa and South Asia regions.[19] Low coverage rates for MNCH interventions, especially among the poor, is a known barrier to progress towards the MDGs.[10, 20] Increased coverage rates should result in better maternal and child health outcomes[17], especially substantially increasing coverage among the poorest individuals.[20]

The Pathway from Financing to Coverage of MNCH Interventions

Since 2003, ODA to maternal, newborn and child health (MNCH) has steadily increased from $2.6 billion in 2003 to $6.5 billion in 2010.[7] Despite the increasing absolute value of ODA, since 2008 the rate of increase has slowed from 20% to 16% to 2.9% in 2008, 2009, 2010 respectively.[7] ODA is used to facilitate the increased coverage of key MNCH interventions and is generally targeted towards countries with high rates of maternal and child mortality.[21] Although targeting of ODA has improved, it has been shown that this targeting is better for ODA to maternal health than ODA to child health.[7, 22]

According to the Countdown to 2015 conceptual framework, the interplay of supportive national policies, health systems and financing should result in increased and equitable coverage of interventions which impacts maternal and child health outcomes.[23] However, there are other characteristics that influence this relationship, such as the political, economic, social, technological and environmental factors within a country.[23]

The WHO World Health Report 2005 [24] states that strong health systems are the foundation of effective MNCH programs. These strengthened health systems ensure that a continuum of care is present from the pre-pregnancy period through childbirth and early childhood, resulting in improved health outcomes. The Maternal and Child Health Integrated Program (MCHIP) presents a framework which further describes how strengthened health systems result in improved MNCH outcomes.[25] In the MCHIP health systems framework, MNCH interventions act upon the three main health system components i.e. the health sector (components including an enabling environment, governance & service delivery such as policies & regulations, financing, the health workforce etc.), the community (the social and physical environment such as population density, socio-cultural characteristics etc.) and households (including socioeconomic characteristics, individual-level factors). The interaction of these components, which encompass intra-country political, economic, social, technological and environmental factors with MNCH interventions, influences the coverage and quality of the interventions, thereby impacting health outcomes. External to this interaction are four health system modifiers: financing (the use & mobilization of funds); organization (the organization of health care provision); regulation (the assortment of legal mechanisms

that change the behavior of individuals and organizations in the health sector); and communication (the methods used to change individual behavior). These act as conduits by which health system initiatives can further effect change in the interaction of the health system and MNCH interventions, also influencing health outcomes.

Health System Factors Associated with Improvements in Health Outcomes

1. Health Sector

Enabling Environments & Policies: Bucagu et al. examined the impact of health system strengthening initiatives in Rwanda on the coverage of maternal interventions, specifically the implementation of a national facility-based childbirth policy, performance based financing and community-based health insurance.[26] The authors found that coverage of 3 key maternal interventions (skilled birth attendance, institutional delivery and use of contraceptives) increased significantly due to the health system initiatives. Other health system components such as political will and country ownership have also been shown to influence the scale-up of health interventions. Bhandari et al. found that the successful scale-up of exclusive breastfeeding was dependent on various factors including political will, enabling policies and sustained financial support.[27] The presence of national policies or implementing bodies to enforce health initiatives can affect the coverage of interventions.

The Health Workforce: Skilled health care workers are an essential component of functional health systems [28]; and health worker density has been shown to be positively associated with health outcomes.[29] For instance, Anand & Barnighausen showed that

increasing the density of nurses was associated with increased vaccination coverage [30]. Kruk et al. found that while positive associations existed between health care workers and the coverage of skilled birth attendants and immunizations, other population level factors influenced coverage rates.[31] For improved MNCH outcomes, the availability of skilled health workers is necessary to ensure that adequate care is provided throughout pregnancy & delivery, infancy and early childhood. However, the countries that face the most critical healthcare worker shortages are in sub-Saharan Africa [32], a region also characterized by the need to accelerate its progress towards reaching MDGs 4 and 5.[9] The health workforce is also affected by HIV prevalence, with the highest rates found in the sub-Saharan Africa countries.[33] HIV prevalence impacts the health workforce by increasing the number of patients requiring health services, expanding the role of healthcare workers to perform other HIV-associated duties such as HIV counseling and providing antiretroviral therapy, and reducing the healthcare work force due to HIV-associated morbidity and mortality. This further strains the health system and may have a negative impact on coverage of essential MNCH services [34], however the integration of HIV and MNCH care services may increase utilization of both services.[35]

Financing of Health Care: Sources of MNCH funding include government expenditures, external expenditures such as donor financing and private spending such as out-of-pocket expenditures (OOP).[23] In 2009, government expenditures on health as a percentage of total expenditure on health for the majority of sub-Saharan African countries was 15% or less with an average of 8.2% for the WHO African Region.[36] Comparably, the region with the highest percentage of GDP spending on health was the WHO Region of the

Americas with 16.9%.[36] Private expenditures include private health insurance and out-of-pocket payments. In the African Region, the average OOP as a percentage of private health expenditure was 61.6% compared to 31.2% in the Americas.[36] Out-of-pocket expenditure is inversely related to coverage of health services and is recognized as a major financial barrier to health care for the poor.[37] However increased spending on health regardless of source, is associated with improved health outcomes.[38]

2. Community

Social Environment: Poverty is an important aspect of the social environment that has adverse effects on health. Poorer individuals are less likely to access health services [39], often live in environments that promote ill health [40] and have higher rates of child and maternal mortality [41, 42]. To fight poverty and reduce its adverse health impacts, governments have introduced pro-poor health policies that prioritize the health of the poor using equitable financing methods such as social insurance and community based health insurance schemes.[43] The main goals of pro-poor policies are to ensure that healthcare costs are proportional to an individual/household's ability to pay, that the indigent are protected from financial catastrophe due to ill health, and that access to health services both in terms of quality of care and geographic location is equitable across socioeconomic strata.[44] Positive associations have been found between pro-poor health policies and health outcomes. Kruk et al. analyzed data from 47 low-income and low-middle income countries and found that a pro-poor distribution of immunization and treatment for acute respiratory infections was associated with lower levels of inequity in under-five mortality inequity than distributions that were not pro-poor.[45] A study in

Kenya found that community based insurance increased access to health services among the poor.[46]

3. Households

Individual & household-level health seeking Behaviors: Individual and household health seeking behaviors are important determinants of health and, consequently, the uptake of MNCH interventions. Several studies have investigated the factors associated with health seeking behaviors for childhood illnesses. In a Nigerian hospital-based study, prompt care-seeking was associated with febrile illness, but not cough or diarrheal illnesses.[47] Among postpartum Nigerian mothers, maternal and infant factors that were significantly associated with appropriate care seeking behavior included younger maternal age, higher education and socio-economic status and infant age less than 1 year.[48] A community based study of Nigerian mothers and their children under five years of age also investigated care seeking behavior.[49] Sixty-six percent of mothers with children who had symptoms suggestive of malaria, pneumonia, diarrhea and measles sought care for their illness. Only 8% of these mothers sought care at the onset of illness, while the rest sought care after self-treatment (68.6%), use of traditional medicines (12.5%) and traditional home care (23.2%).[49] Among Ethiopian mothers seeking care for childhood illnesses, higher socio-economic status of the mothers or caregivers was associated with prompt care seeking.[50] A Ugandan study found that the majority of mothers perceived fever to be the most serious health problem compared to upper respiratory or diarrheal illnesses.[51] Mothers of children with febrile illnesses were more likely to seek care, and care was sought at health clinics only after self-treatment attempts had failed and the disease had progressed. This study noted that significant barriers to accessing care

included distance to health facilities, lack of drugs and poor quality of care from the health workers.[51] A qualitative study in Malawi determined that despite high levels of malaria knowledge, levels of prompt and appropriate treatment were low.[52] Most children were initially treated at home with ineffective regimens. Delayed care seeking from an appropriate health care provider was associated with reliance on traditional medicine and health system issues such as unavailability of medications, and other barriers in accessing health care.[52] In a Kenyan study, illness perception was noted as a significant barrier to seeking care for children.[53] Factors that were associated with care seeking included febrile illnesses, young child age and higher household income.[53]

The Relationship between ODA and MNCH Coverage Rates

Few studies have examined the relationship between ODA and coverage rates of MNCH interventions or health outcomes. Findings from these studies have not been consistent: some have shown a positive relationship and others have shown no impact of ODA on health outcomes. Taylor et al. examined the relationship between ODA and reproductive health outcomes (MDG 5), specifically the delivery of aid according to the Paris Principles, i.e., taking into account country ownership, alignment between donors and recipients, harmonization of aid processes, focus on producing and measuring results and mutual accountability.[54] The Paris Principles, embodied in the 2005 Paris Declaration on Aid Effectiveness, were developed as a global commitment to ensure that development aid improved health and other economic outcomes.[55] Although the study found that there were small improvements in health outcomes, these improvements could not be linked to the mode of aid delivery. In addition, there was little explanation on the

role of confounding factors and other plausible theories in the association found. Snow and colleagues found that despite overall increases in ODA for malaria, countries with the high burden of disease levels received funds that were inadequate to improve the coverage of preventive and curative strategies.[56] Another study found that in low income countries, disbursed ODA per capita targeted to efforts to improve water and sanitation was associated with increased population access to improved water supplies, although not with access to improved sanitation.[57] A recent effort to describe the broader determinants of changes in health services coverage found no significant associations between annual changes in levels of total ODA inflow per capita and trends in coverage rates for DPT, TB detection, TB treatment completion rates and the presence of a skilled attendant at birth, after controlling for country-specific baseline levels of coverage and rates of change.[58]

To ensure better health outcomes, it is important to understand the complex pathway that leads to increased coverage. Increased financing, national policies, and a strong health system are important factors, but their interplay with individual and household behaviors as well as country characteristics cannot be overlooked. With vast financial investments in health, it is important to understand the impact of financing and identify opportunities for improvement, to maximize the efficiency of donor financing. The analyses presented in this dissertation seek to further understand the relationship between increasing levels of ODA and change in coverage rates by:

1. Determining the impact of ODA on the change in coverage levels of MNCH interventions.

This will address the dearth of studies that have analyzed the relationship between ODA for health and coverage levels of MNCH interventions. The analysis is a multi-country analysis examining changes in ODA levels and the impact on the coverage of MNCH interventions, and will consider factors along the pathway from increased ODA to increased coverage such as HIV prevalence, maternal education levels and health worker density in order to explain this complex relationship. This paper will add to the present body of knowledge on ODA to health and present a systematic analysis detailing the impact found.

2. Further deconstructing the relationship between ODA and changes in coverage of health interventions by analyzing the different metrics that have been used in measuring coverage change.

Because there is no standard metric for measuring coverage change, this analysis seeks to describe the metrics used in measuring coverage change worldwide and to assess the implications of the choice of metric for the results obtained and judgments on progress. This paper will serve as an informative resource to researchers and other stakeholders on the metrics being used to compute coverage change and the impact and interpretation of their findings.

3. Describing the utilization of maternal health interventions in a country with pro-poor policies & increased levels of financing.

There are various methods for monitoring the impact of pro-poor policies and increased financing, including examining health services utilization by socioeconomic group.[44] This analysis seeks to describe factors that are associated with the use of maternal health interventions in a country with established pro-poor policies as well as increased levels of maternal health ODA. This paper will further analyze a subset of the data from the previous analysis on the impact of ODA on the coverage of MNCH interventions, focusing Nigeria, the country with the highest amount of ODA to maternal health. The distribution of maternal health utilization among women of varying socioeconomic status in the presence of pro-poor policies and increased financing will be examined. This paper will contribute to the body of knowledge on factors affecting the uptake and utilization of maternal health services in the face of increasing ODA and appropriate health policies.

Methods

Paper 1: Does official development assistance predict levels and changes in coverage for proven maternal, newborn and child health interventions? Analyses from 26 Countdown to 2015 priority countries in sub-Saharan Africa.

Data Sources

1. Demographic Health Survey (DHS, http://www.measuredhs.com/)

The Demographic and Health Surveys (DHS) project provides data on the population, health and nutrition status of women and children in developing countries [59]. Started in 1984, it has collected data in 84 countries, including HIV testing in 30 countries, and provides data and analysis on the population, health, and nutrition of women and children in developing countries. Information on child mortality, maternal and child health, family planning and other reproductive health issues are provided [59]. The surveys use a stratified multistage cluster sample design to collect nationally representative samples of the population. For a full description of the study design or sampling methodology, see Measure DHS at www.measuredhs.com. These surveys are typically conducted every five years.

2. Multiple Indicator Cluster Surveys (MICS)

MICS is an international nationally representative household survey that was established by The United Nations Children's Fund (UNICEF) as a result of the 1990 World Summit for Children.[60] MICS collects data on a range of health, education, child protection and HIV/AIDS indicators for mothers and children in developing countries and is an important source of data for tracking the MDGs. MICS is carried out by government

organizations with technical support from UNICEF and other agencies. The MICS survey is harmonized with the DHS and other household survey tools. MICS has been conducted in four rounds during the periods: 1995, 2000, 2005-2006 and 2010-2011. Initially, the surveys were conducted every 5 years, however to assist with rapid assessment of health changes, UNICEF has proposed conducting the surveys at three-year intervals. For a full description of the study design or sampling methodology, see MICS at http://www.childinfo.org/mics.html.

3. Official Development Assistance Data

All ODA data were drawn from the estimates developed for Countdown to 2015 using the aid activities database of the Organisation for Economic Co-operation and Development (OECD); detailed descriptions of these data bases and the methods used to develop the estimates are available elsewhere [21].

Outcome Variables

i. The absolute level of coverage, based on reanalysis of the most recent MICS or DHS data in each country.

ii. The annualized change in coverage between the two surveys.

Predictor variables

i. ODA to maternal and newborn health per live birth was used as the predictor for modeling intervention coverage outcomes for antenatal care and skilled attendant at birth.

ii. ODA to child health per under-five child was used as the predictor for modeling intervention coverage outcomes for insecticide-treated nets, exclusive breastfeeding, oral rehydration therapy and care seeking for childhood pneumonia from an appropriate health provider.

iii. Baseline coverage, defined as the intervention-specific coverage level obtained from reanalysis of data from the first of the two surveys in each country.

iv. Mean number of years of schooling, as reported on the woman's survey questionnaire.

v. A combined measure of good governance that measures perceptions of political stability and absence of violence as reported by the Worldwide Governance Indicators Project (WGI, http://info.worldbank.org/governance/wgi/index.asp

vi. HIV prevalence among adults aged 15 to 29 as estimated by UNAIDS.

vii. National estimates of health worker density per 1,000 population as reported by Countdown to 2015 in 2008.

viii. Estimates of national gross domestic product, from the same source as out-of-pocket expenditures.

ix. National estimates of out-of-pocket expenditures on health (OOP) as a percentage of total expenditure on health obtained from the World Development Indicators and Global Development Finance, World Bank Databank.

Statistical Methods

1. Coverage Rate Estimates. Coverage rates, the main outcome variables, were recalculated using MICS or DHS survey data for each country. The coverage rates

and the standard errors were estimated using the survey data analysis module available in STATA 11.[61] The module accounts for the complex sampling design of MICS and DHS surveys. The calculated estimates were compared with the official figures in the DHS/MICS reports, and any differences were reconciled by consulting survey staff members or by adhering to the standard definitions of the coverage indicators used in the Countdown to 2015.[62]

2. Estimating annualized change in coverage. We estimated annualized change in coverage rates using generalized linear models with an identity link and binomial distribution, with year of survey as the main predictor. We used variance estimates that are robust to model misspecification known as Huber/White/sandwich variance estimator as described by Huber [63] and White [64]. The estimator is generalized to clustered data where the observations within cluster are not independent, but the clusters themselves are independent (e.g., regions within a country). The "meat" of the sandwich is substituted by a matrix that represents the outer product of *cluster-level* scores, where within each cluster the cluster-level score is obtained by summing the observation-level scores.[65]
3. Regression models. To explore the effect of the covariates (including ODA) on the coverage outcomes, we used random-effects meta-regression models on country-level coverage data to account for both between- and within-country variability of coverage estimates. The meta-regression method [66] is implemented using the *metareg* command available in Stata.[67] As implemented in STATA, the beta coefficients are estimated using the restricted maximum likelihood (REML) algorithm that maximizes residual (restricted) log-

likelihood.[68] The method first estimates the between-country variance, and then uses weighted least-squares to estimate the beta coefficients.

4. Random or mixed-effects meta-regression assumes that the underlying country-specific coverage rates, θ_i vary among the countries and follow a normal distribution with a common mean, θ. For a coverage rate in the i'th country, θ_i the model can be represented as:

$$\hat{\theta}_i = \theta + u_i + \varepsilon_i = \beta X_i + u_i + \varepsilon_i$$

where u_i are the country-level random-effects that are normally distributed with zero mean and τ^2 – between-country variance, and ε_i are the residuals, which are also normally distributed with zero mean and σ^2 – country-specific variance.

5. Selection of covariates was achieved by looking at the proportion of between-country variance explained by the set of the covariates in the model, adjusted R-squared. The adjusted R-squared is calculated by the *metareg* program in STATA and represents the proportion of the relative reduction in the overall between-study variability:

$$\hat{R}^2{}_{adj} = \frac{\widehat{\tau^2}_0 - \widehat{\tau^2}}{\widehat{\tau^2}_0}$$

where $\widehat{\tau^2}_0$ is the estimated overall between-country variance in the model with no covariates, and the τ^2 is the estimated between-country variance in the model with the given set of covariates.

6. As noted by Harbord and Higgins [67], the adjusted R-squared can be negative if the set of covariates explains less of the between-country variability than expected by chance.

Paper 2: Metrics for Measuring Change in Population Coverage for MNCH Interventions: A Systematic Review.

Data Sources

A search for articles that had quantified change in levels of intervention coverage for contraceptive prevalence, child immunizations (a combination of measles, DPT3, Hib immunization indicators) and infant feeding was conducted in four databases: Pubmed [69], a free online portal that provides access to Medline, the National Library of Medicine database covering approximately 5400 journals with over 22 million citations and abstracts; Embase [70], a database with access to over 7600 journals and over 24 million citations covering Medline as well as over 5 million citations not included in Medline; Popline [71], the largest database on family planning and reproductive health worldwide; and Scopus [72], the largest abstract and citation of literature worldwide with 47 million citations covering the scientific, technical, medical and social science fields. Of note, Pubmed, Embase and Scopus all provide citations from Medline, however these databases also independently provide access to unique resources. These databases were last searched on 30 November 2011. Articles were included in the analysis if they were published in English since 1990. We used date of publication as the criterion because we expected that articles assessing coverage change would be likely to include historical

data. Coverage measurements had to occur at two or more time points, and the article had to report on a quantified metric of coverage change.

Methods

A systematic review is a process of systematically identifying literature that addresses a research question of interest using pre-specified criteria; the goal of this review is to perform an exhaustive search to ensure that all relevant research articles are identified.[73] This review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines which uses a 27-item checklist and flow diagram to improve the reporting of systematic reviews.[74]

The data selection process was conducted in four steps by two reviewers to ensure data accuracy and quality. First, all articles found using our search terms were imported into the Endnote reference management software [75] and duplicate articles were screened for and deleted. Second, the titles of the articles were screened for potential study inclusion and relevant titles were selected. Using a conservative approach, any article that was identified for inclusion by either reviewer was retained for further review. Third, the abstracts of all selected articles were reviewed and a further subset of eligible articles was created for potential data abstraction. Again, any abstract that was identified for inclusion by either reviewer was retained for further analysis. Finally, full manuscripts were obtained for all articles that were selected for data abstraction. Full text screening of the manuscripts was performed and data abstracted from eligible articles. Article selection

occurred between October and November 2011. An assessment of the risk of bias in the individual studies reviewed was not conducted because our objective was to determine the metrics used to describe coverage changes, rather than to determine the actual rate of change in coverage for specific indicators.

PRISMA Checklist

	Checklist item	Status
	TITLE	
1	Identify the report as a systematic review.	✓
	ABSTRACT	
2	Provide a structured summary including, as applicable: background, objectives, data sources, study eligibility criteria, results, limitations, conclusions and implications of key findings	✓
	INTRODUCTION	
3	Describe the rationale for the review	✓
4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes and study design.	✓
	METHODS	
5	Protocol and registration	N/A
6	Eligibility criteria	✓
7	Describe all information sources and date last searched.	✓
8	Present full electronic search for at least one database such that it can be repeated.	✓
9	State the process for selecting studies.	✓
10	Describe method of data extraction from reports	✓
11	List and define all variables for which data were sought	✓
12	Risk bias in individual studies	N/A
13	State the principal summary measures	✓
14	Synthesis of results	N/A
15	Risk bias across studies	N/A
16	Additional analyses	✓
	RESULTS	
17	Study selection with a flow diagram	✓
18	Study characteristics for each study	✓
19	Present data on risk of bias	N/A
20	Result of individual studies	N/A
21	Synthesis of meta-analyses	N/A
22	Risk bias across studies	N/A
23	Additional analyses	✓
	DISCUSSION	
24	Summarize the main findings	✓
25	Limitations should be discussed at outcome and study level.	✓
26	Conclusions	✓
27	Funding	✓

Paper 3: Utilization of maternal health interventions among women with varying socioeconomic status.

Data Sources

Data from the 2008 Nigeria Demographic Health Survey (DHS) [76] were used in this analysis. This is a nationally representative household survey that used a multistage sampling technique. A total of 888 clusters consisting of 286 urban and 602 rural clusters are represented. A final cluster size of 886 was used due to inaccessibility of 2 clusters. These clusters resulted in a sample of 36,800 households within all the six geopolitical zones in Nigeria. Three questionnaires were used in this survey: the household questionnaire collected information on the household listing including age, sex, education, residence, household characteristics including drinking water source, sanitation, household assets and nutritional status of women and children; the women's questionnaire collected information on socio-demographic characteristics, reproductive behavior, contraception, care before, during and after delivery, infant feeding, children's health; the men's questionnaire collected information on socio-demographic characteristics, reproduction, contraceptive knowledge and use, employment and other health issues. The questionnaires were administered to all women between the ages of 15 and 49 who lived or visited the households the night prior to the survey. Men between the ages of 15 and 59 in every other household who lived or visited the night prior to the survey were also interviewed. The final sample of eligible women and men interviewed was 33,385 and 15,486 respectively. The overall response rate for women was 95% and men 91%.

Measure DHS Wealth Quintiles [77]

Measure DHS computes the wealth index based on responses in the household DHS question. The household questionnaire collects data on the ownership of a variety of household items and the responses are used to construct a wealth index using Principal Components Analysis (PCA)[78]. Households are separated into five wealth quintiles from the lowest to the highest wealth quintile and this serves as a composite measure of wealth. The wealth indexes are provided by Measure DHS and require no further computation by the researcher. For further information, see http://www.measuredhs.com/pubs/pdf/CR6/CR6.pdf

Outcome Variables

Maternal health service utilization was the dependent variable in this study and defined as (1) the use of a skilled birth attendant or (2) having 4 or more antenatal care visits. These two indicators are used to monitor progress towards maternal health goals (MDG 5).[79] Both dependent variables are defined as indicator variables with use of service coded as 1 and non-use coded as 0. Separate analyses were conducted for each dependent variable.

Predictor Variables

Socioeconomic and demographic predictors of maternal health service utilization were included in this analysis. Maternal age (6 categories), age at first birth (5 categories), parity (1 to 4 or more deliveries), maternal educational level (none, primary level or secondary or higher level), current maternal employment (yes or no), ethnicity (Ibo,

Yoruba, Hausa and other), religion (Christian, Muslim and other), locality (rural or urban residence), region (North or South).

Statistical Methods

1. A chi-squared test [80] was used to test for associations between the outcome and predictor variables.

   The ***chi-square test statistic*** is computed as

   $$X^2 = \sum \frac{(\text{observed - expected})^2}{\text{expected}}$$

2. Bivariate and multivariate models for logistic regression [81] were utilized for predicting the outcome of the categorical outcome variables (the use of 4+ ANC visits or skilled birth attendant, yes/no) based on one or more predictor variables.

   Log odds = $b_0 + b_1x_1 + b_2x_2$

Paper 1: Does official development assistance predict levels and changes in coverage for proven maternal, newborn and child health interventions? Analyses from 26 Countdown to 2015 priority countries in sub-Saharan Africa

Abstract

Background

The provision of official development assistance (ODA) for maternal, newborn and child health is based in part on the assumption that additional ODA will lead to accelerations in coverage for interventions proven effective in reducing maternal and child mortality. We investigated this assumption in 26 countries in sub-Saharan Africa, as part of the cross-cutting research program of Countdown to 2015 for Maternal, Newborn and Child Survival.

Methods and Findings

We reanalyzed nationally-representative household surveys in 26 sub-Saharan countries with at least two surveys conducted between 2000 and 2008 to determine recent coverage levels and the annualized change in coverage for six proven interventions in the continuum of care from maternal through newborn and child health. For each outcome, the optimal model was defined as the set of covariates associated with the highest explained between-country variability in the outcome measured by the adjusted R-squared. The candidate variables (in addition to ODA per live birth/per child) included baseline coverage level, mean years of education among adult women, governance

indicators for political stability and absence of violence, health worker density, adult HIV prevalence, gross domestic product per capita and out-of-pocket expenditure as a percentage of total health expenditure.

The amount of ODA was positively associated with levels and changes in coverage for correct treatment of childhood diarrhea and with levels of exclusive breastfeeding and the presence of a skilled attendant at birth. Differences of $1 in ODA to child health per child were, on average, associated with estimated increases of 1.1 percentage points in ORT coverage (p=0.050), with increases of 0.27 percentage points in annualized change in ORT coverage (p=0.014), and with increases of 0.8 percentage points in the prevalence of exclusive breastfeeding (p=0.086). We also found that a $1 difference in ODA to maternal and newborn health per live birth was associated with an estimated increase of 0.04 percentage points in the annualized change in the proportion of women who report the presence of a skilled attendant at birth (p=0.095). A significant proportion of between-country variability in coverage levels was explained by the optimal models for some interventions and not others. The findings should be generalized with care because there are limitations in the data available for analysis and the 26 countries we were able to study differ in important ways from the 16 remaining Countdown countries in sub-Saharan Africa.

Conclusions

There are important differences in the determinants of coverage levels and change across interventions, and further research is needed to understand these patterns and their

implications for public health programs and the role of ODA. More and better data – particularly on ODA – are needed to support ongoing research on the determinants of intervention coverage.

Introduction

Countries have made variable progress in achieving Millennium Development Goals 4 (for child survival) and 5 (for reproductive health and maternal survival), with some being on track and others, especially in sub-Saharan Africa, lagging behind [82-85]. Most governments and partners have adopted strategies that focus on achieving high coverage with interventions of proven effectiveness in reducing fertility and maternal, newborn and child mortality [86] as the way forward, recognizing that accelerated coverage is also an outcome of strengthened health systems. Countdown to 2015 for Maternal, Newborn and Child Survival tracks coverage for high-impact interventions in countries responsible for over 97% of deaths among women and children worldwide, and uses the results to hold countries and their partners accountable for progress [87].

Official development assistance (ODA) to maternal, newborn and child health increased in absolute terms between 2003 and 2008 (although not as a percentage of overall ODA for health), and is increasingly targeted on countries with high rates of maternal and child mortality [21, 22]. The resources are usually flexible although they are often earmarked by donors for use in accelerating coverage for specific interventions.

Few previous studies have addressed the commonly-held assumption that increases in ODA to health programs will lead to accelerations in coverage for high-impact interventions. Snow and colleagues found that despite overall increases in ODA for malaria, countries with the majority burden of disease received funds that were inadequate to improve the coverage of preventive and curative strategies [56]. Several

groups have also tried to address this relationship in the area of immunization programs. A recent assessment of the impact of Immunization Services Support (ISS) funding from the GAVI Alliance on immunization coverage rates (DPT3) in 52 countries between 1995 and 2005 found that after controlling for gross domestic product (GDP) and a measure of political stability, ISS funding had a significant positive effect on DPT3 coverage rates in each of the two years after funding was received [88]. GDP and the presence of current conflict in a country had a significant negative correlation with the effect of ISS funding on DPT3, and political stability had a significant positive effect. These findings contradict those of an earlier analysis that found no effect [89], and this discrepancy is explained by the authors of the later study as due to their use of more complete data sets and actual ISS expenditures rather than disbursements as the main predictor or explanatory variable. Another study found that in low income countries, disbursed ODA per capita targeted to efforts to improve water and sanitation was associated with increased population access to improved water supplies, although not with access to improved sanitation [57]. A recent effort to describe the broader determinants of changes in health services coverage found no significant associations between annual changes in levels of total ODA inflow per capita and trends in coverage rates for DPT, TB detection, TB treatment completion rates and the presence of a skilled attendant at birth after accounting for country-specific baseline levels of coverage and rates of change [58]. Matsubayashi and colleagues also demonstrated that levels of coverage at the national level change at different rates across countries [58]. The present analysis uses statistical techniques that take heterogeneity across countries into account. In addition, this study draws on the Countdown estimates of ODA directed specifically at maternal and newborn

or child health rather than overall ODA, and focuses on a wider range of maternal and child health interventions.

In this paper we report on our efforts to describe the relationship between ODA and coverage for high-impact reproductive, maternal, newborn and child health interventions as a part of the Countdown to 2015 program of cross-cutting research. The conceptual framework for Countdown, in its simplest form, assumes that policies and financial flows operate through health systems variables to affect coverage, recognizing the importance of contextual factors at country level [87]. This study is the first in a program of research on the determinants of coverage levels and trends, building on the data sets managed by Countdown Technical Working Groups (Coverage, Financial Flows, Health Systems and Policy, Equity). Here we explore relationships between ODA and coverage in the 26 Countdown countries in sub-Saharan Africa where at least two nationally-representative household surveys were conducted between 2000 and 2008.

This study does not address a second critical assumption – that increases in population coverage with interventions of proven efficacy will accelerate declines in mortality and fertility in relevant population groups. This assumption is best addressed through large-scale public health effectiveness evaluations [90] supplemented by rigorous country case studies [83].

Methods

We hypothesized that after accounting for prior coverage levels and country-level characteristics assumed to affect coverage, higher levels of ODA in the recent past would be associated with higher levels of intervention coverage and with larger increases in coverage over time. In this section we describe the country selection criteria, the selection and definition of predictor and outcome indicators, model selection for each outcome and the analytic approach.

Countries included in the analysis

We began with the 68 countries included in the 2008 round of Countdown monitoring, selected based on their high burden of maternal and child mortality [23]. The analysis was limited to the 42 Countdown priority countries in sub-Saharan Africa to reduce contextual variation. Only countries with at least two nationally-representative household surveys conducted between 2000 and 2008 that included standard measurements of coverage for high-impact interventions tracked through the Countdown effort were included, to allow measurement of change over time. Two types of surveys were included: Demographic and Health Surveys (DHS, http://www.measuredhs.com/) and Multiple Indicator Cluster Surveys (MICS, http://www.unicef.org/statistics/index_24302.html). Application of these selection criteria resulted in a sample of 26 countries. Figure 1 presents a flowchart of the selection process; Table 1 shows the DHS and MICS surveys and corresponding year of ODA data used in the analysis. Three eligible surveys had been conducted in Malawi (DHS 2000,

2004; MICS 2006); the MICS was not used in the analysis because the comparability of measurement was assumed to be greater for the two DHSs.

Selection of Outcome Measures

The outcome of interest in this analysis is intervention coverage, defined as the proportion of the population who needs an intervention who actually receives it. We selected the interventions from among those tracked by Countdown [23] that met the following criteria:

- Coverage measurement for the intervention based solely on survey data, rather than a combination of program reports and survey data. Coverage estimates for vaccinations, vitamin A supplementation and prevention of mother-to-child transmission of HIV were excluded from analysis for this reason.
- The coverage indicator for the intervention was measured in comparable ways in DHS and MICS surveys conducted between 2000 and 2008. For example, coverage indicators for postnatal care were excluded from analysis because they were not measured in comparable ways by DHS and MICS during this period.

We selected six out of 26 interventions, taking care to ensure that the set of interventions was distributed across the continuum of care from maternal through newborn and child health: 1) the presence of a skilled attendant at birth; 2) at least one antenatal care visit by a skilled health provider; 3) the proportion of under-five children reported to have slept under an insecticide-treated net the previous night (all 26 countries in the analysis are endemic for malaria); 4) exclusive breastfeeding up to six months; 5) children under five years of age with diarrhea reported to have been given oral rehydration therapy

(increased fluids and continued feeding); and 6) children under five years of age reported to have signs and symptoms of pneumonia who were taken to an appropriate health provider. Appendix 1 lists all Countdown coverage indicators and the basis for the selection analyzed in this study. Definitions for each indicator are available at http://www.countdown2015mnch.org/. We originally included the contraceptive prevalence rate because we anticipated specific data on ODA to family planning to become available during the course of our analysis. This did not happen and the results for CPR are therefore not included in this paper.

Two coverage variables were constructed for each intervention: 1) the absolute level of coverage, based on reanalysis of the most recent MICS or DHS data in each country; and (2) the annualized change in coverage between the two surveys. The annualized change in coverage variables for each country was estimated using generalized linear models with coverage as the outcome variable and the year of survey as the predictor variable. Robust variance estimates [68] were used to account for geographical clustering of coverage data within each country. The beta coefficient represents the estimated average change in coverage per year, i.e., annualized change. We used the beta coefficient and its standard error from this model as the outcome variables in the main models looking at the effect of ODA on annualized change in coverage. Further details on construction of the coverage variables are available in Appendix 2.

Selection of Predictor Variables

We used two different measures of ODA as predictor variables: 1) ODA to maternal and newborn health per live birth was used as the predictor for modeling intervention coverage outcomes for antenatal care and skilled attendant at birth; and 2) ODA to child health per under-five child was used as the predictor for modeling intervention coverage outcomes for insecticide-treated nets, exclusive breastfeeding, oral rehydration therapy and care seeking for childhood pneumonia from an appropriate health provider. For each country we used the most recent available estimate of ODA that was at least two years prior to the measured level of coverage. Unlike earlier studies that examined the relationship between GAVI investments and immunization coverage either in the same year or one year later [88, 89], we assumed that a period of two years would be needed for ODA disbursements to be received at country level, translated into program actions and result in coverage change for the interventions under study (*personal communication, Peter Berman, 1 October 2010)* . The exception was three countries in which the more recent of the two surveys was in 2004 (Chad, Lesotho, Malawi), permitting only a one-year lag given that our earliest ODA estimates were from 2003. All ODA data were drawn from the estimates developed for Countdown to 2015 using the aid activities database of the Organisation for Economic Co-operation and Development (OECD); detailed descriptions of these data bases and the methods used to develop the estimates are available elsewhere [21]. All estimates of ODA are disbursements expressed in real 2005 United States dollars.

We identified other covariates expected to affect intervention coverage through reviews of earlier studies and preliminary analyses of relationships between the candidate

variables and our intervention coverage outcome variables. They included: 1) baseline coverage, defined as the intervention-specific coverage level obtained from reanalysis of data from the first of the two surveys in each country; 2) mean number of years of schooling, as reported on the woman's survey questionnaire*;* 3) a combined measure of good governance that measures perceptions of political stability and absence of violence as reported by the Worldwide Governance Indicators Project (WGI, http://info.worldbank.org/governance/wgi/index.asp, additional information on the WGI methodology is available elsewhere [91]); 4) national estimates of health worker density per 1,000 population as reported by Countdown to 2015 in 2008 [92]; 5) HIV prevalence among adults aged 15 to 29 as estimated by UNAIDS [93]; 6) national estimates of out-of-pocket expenditures on health (OOP) as a percentage of total expenditure on health obtained from the World Development Indicators and Global Development Finance, World Bank Databank [94]; and 7) estimates of national gross domestic product, from the same source as out-of-pocket expenditures. With the exception of baseline coverage and health worker density, we selected the data point for each covariate that was closest to but not later than two years prior to the most recent measure of intervention coverage used for each country in the analysis. Although we tried to avoid the use of measures of population health such as under-five mortality and fertility as covariates in the models for reasons of circularity, HIV prevalence was included due to its potential importance as a more direct factor affecting levels of intervention coverage and government and donor investment in maternal and child health.

In the annualized change models, the number of years between the surveys was not considered as a covariate. Upon examination, no relationship between annualized change in coverage and number of years between the surveys was found.

Analytic Approach

We performed random-effects meta-regression [95] on country-level summary data to estimate the effect of ODA on levels and changes in coverage. We focus here on three models for each of the two intervention coverage outcomes (levels and changes). The first model includes only the baseline coverage rate. The second model includes the baseline coverage rate and the relevant measure of ODA (per live birth or per child). To select the third or "optimal" model, we ran model 2 as the base model and sequentially entered covariates in the same order for all outcomes i.e. baseline coverage, ODA (per live birth or per child), maternal education, governance, health worker density, HIV prevalence, OOP and GDP. We noted the adjusted R-squared for the sequential models. The optimal model included the set of covariates that explained the highest proportion of between-country variability in the outcome which in some cases was model 2. Appendix 2 provides additional details on the methods.

All analyses were conducted using STATA 11 [61].

Results

We first present descriptive information about the 26 countries included in the analysis, the relationship between these characteristics and the coverage outcomes and the

bivariate relationship between ODA and intervention coverage measures. Subsequent sections summarize the results on the predictive value of ODA and other covariates relative to levels and annualized change in intervention coverage.

Country characteristics and bivariate relationships

Table 2 compares selected characteristics of the 26 countries included in the analysis with the remaining Countdown countries in sub-Saharan Africa. For the measures of population health presented here but excluded from the modeling, the 26 countries with sufficient data to be included in the analysis had significantly higher crude birth rates ($p = 0.027$) and nearly significantly higher rates of fertility ($p=0.063$). Included countries also appear to have lower levels of literacy among adult women ($p = 0.060$). No significant differences were found between countries included and excluded from the analysis for the candidate covariates with the exception that included countries had dramatically lower gross domestic products per capita than those excluded. A list of included countries is available in Table 1; the excluded countries are Angola, Botswana, Central African Republic, Congo, Djibouti, Equatorial Guinea, Eritrea, Gabon, Guinea, Liberia, Mozambique, Somalia, South Africa, Sudan, Tanzania and Zimbabwe.

Tables 3a and 3b show the estimated linear correlation coefficients (r) for the relationships between candidate covariates and the outcome measures of level and annualized change in intervention coverage, respectively. The candidate covariates generally have a positive relationship with the levels of intervention coverage with the

exception of out-of-pocket expenditures which tends to be negatively correlated. There is no other clear pattern of associations.

Graphical plots showing the bivariate relationship between the main predictor variables (measures of ODA to maternal and newborn health and to child health) and levels and changes in intervention coverage are available in Appendix 3 and generally show weak positive associations. We identified three potentially influential data points indicating very high levels of ODA (ODA to maternal and newborn health in Burundi and Zambia, and ODA to child health in Zambia). These points are highlighted in Appendix 3. Here we report all results including these three data points; results for final models excluding these three points are available in Appendix 4.

Effects of ODA on levels of coverage

Tables 4 and 5 present the results of the three meta-regression models for each outcome, showing the adjusted R-squared for all models and the beta coefficients for ODA variables in models 2 and 3. Table 4 examines the effect of ODA and other covariates on the most recent levels of intervention coverage. The results suggest that a significant proportion of between-country variability in coverage levels can be explained by the selected candidate covariates, and especially baseline coverage. Excluding ORT, which appears to be an outlier, the proportion of explained between-country variation in coverage levels ranged from 52.9% for ITNs to 84.8% for skilled attendant at birth.

The addition of ODA to the model increased the amount of variability explained for some interventions and not others. For example, 77% of between-country variability in exclusive breast feeding coverage in the latest available survey can be accounted for by including baseline coverage and ODA to child health in the model. We observed a marginally significant, positive association between ODA and the level of exclusive breastfeeding, indicating that given the same level of baseline coverage, every $1 difference in ODA to child health is on average associated with a 0.8 percentage point greater prevalence of exclusive breastfeeding over a two-year period (95%CI: -0.1 to 1.7 percentage points, p-value = 0.086) (see Table 4).

There was also a significant positive association between ODA to child health and level of coverage for oral rehydration therapy (ORT) after adjusting for baseline coverage. In other words, given the same level of baseline coverage, every $1 difference in ODA to child health is on average associated with 1.2 percentage points greater ORT coverage (95%CI: from 0.4 to 2.0 percentage points higher, p-value = 0.005). The adjusted R-squared for this model was 25%. The adjusted R-squared for the optimal model that included maternal education, measures of governance and health worker density, HIV prevalence, out-of-pocket expenditures and gross domestic product was 59%. The beta coefficient for ODA did not change to a meaningful degree in this model.

Effect of ODA on the annualized change in coverage for selected interventions

Table 5 shows the results of meta-regression models examining the effect ODA on annualized change in intervention coverage. As would be expected, the proportion of

explained between-country variability was less pronounced for changes in coverage than for levels of coverage for all interventions with the exception of ORT, and ranged from -7.5% for skilled attendant at birth to 22.2% for ITNs. For example, the "optimal" model for predicting changes in coverage for a skilled attendant at birth had an adjusted R-squared of 7.3% and included only the baseline coverage level and ODA to maternal and newborn health (i.e., it was identical to the second model). The effect of ODA on annualized change in presence of a skilled attendant at birth after accounting for baseline coverage was marginally significant (p-value = 0.095). Given the same level of baseline coverage, every $1 difference in ODA to maternal and newborn health is on average associated with 0.04 percentage point greater annualized change in the proportion of women who report the presence of a skilled attendant at birth (95% CI from -0.01 to 0.09 percentage points).

The strongest positive association was again found in the relationship between ODA to child health and annualized change in coverage for ORT; the model that included baseline coverage and ODA to child health had an adjusted R-squared of 89%. Inclusion of maternal education, measures of governance and health worker density, HIV prevalence, and proportion of out-of-pocket expenditures and gross domestic product in the model for annualized change in ORT increased the adjusted R-squared to 93%. Given the same level of baseline coverage and all other variables in the model, every $1 difference in ODA to child health is on average associated with an estimated 0.27 percentage point greater annualized change in coverage for ORT (95%CI: from 0.06 to 0.47, p-value = 0.014).

Discussion

Programmatic efforts to scale-up population coverage for proven, cost-effective interventions should be informed by evidence about the determinants of coverage levels and changes. With few exceptions [58, 96], however, studies of the determinants of coverage to date have focused on single program areas, often in individual countries, and rarely include measures of ODA. We report here on a multivariate regression analysis of the relationship of ODA to maternal and newborn or child health and coverage levels and changes for a selection of proven interventions across the continuum of care from reproductive through maternal and newborn to child health.

We performed a cross-sectional analysis of ecological country level data. Our results indicate that ODA to child health is positively associated with coverage levels and changes for ORT, and marginally positively associated with exclusive breastfeeding. Every $1 difference in ODA to child health per child is on average associated with 1.2 percentage points greater ORT coverage (p=0.005), with 0.32 percentage points greater annualized change in coverage for ORT (p=0.004), and with 0.8 percentage point greater prevalence of exclusive breastfeeding (p=0.086). We also found that every $1 difference in ODA to maternal and newborn health per live birth is on average associated with 0.04 percentage points greater annualized change in the proportion of women who report the presence of a skilled attendant at birth (p=0.095). Assuming the relationship between ODA and coverage is linear, and using average rates of increase across the 26 countries in the analysis, a broad finding is that countries that had an extra $1 in ODA per child

appeared to have about one percentage point greater coverage levels for oral rehydration therapy and exclusive breastfeeding. These findings are suggestive, and further research is needed to understand the pattern of results and their variability across interventions.

The pattern of relationships between ODA and coverage across the interventions we examined was not what we expected. Based on characteristics such as recent donor interest, the complexity of the intervention and how it is delivered and the probable sensitivity of the coverage measurement, we would have expected coverage for insecticide-treated nets to be more responsive to increases in ODA than exclusive breastfeeding and oral rehydration therapy. We did not expect to find strong associations between ODA and antenatal care or the presence of skilled attendant at birth. For the latter intervention, especially, the pathway from investment to delivery is long, requiring considerable training and infrastructure development. Also, for both of these interventions the recall periods for this intervention (two years in MICS and five years in DHS) are long relative to the time frame used for the ODA variable, and data limitations forced us to assume that levels were stable over these periods. In continuing analyses we will expand the interventions to include those – such as immunizations and vitamin A supplementation – that could be expected to respond to ODA more quickly.

One finding that will be important for future research and programming is that the determinants of coverage appear to vary by interventions across the continuum of care. The baseline coverage level – known previously to be an important determinant of coverage changes for immunization [88, 89], TB treatment and the presence of a skilled

attendant at birth [58] -- was also found to play an important role in the interventions studied here, and influenced levels of coverage for different interventions. The optimal models included different sets or numbers of covariates across the interventions studied. Continuing efforts to understand the determinants of change in coverage should avoid aggregate outcome measures that combine multiple interventions, at least until these relationships are better understood.

These findings are suggestive, but we reiterate calls by others for more and better data on ODA [58, 88, 97]. ODA estimates are derived from the Creditor Reporting System (CRS) Database on aid activities that is developed and maintained by the OECD. It has been noted that the majority of disbursements on health activities are captured by the CRS, however there are some important limitations. Missing data for some of the largest donors exist, multilateral institutions voluntarily report to the CRS with some donors reporting commitments and others disbursements, and aid activities are sometimes poorly described which may lead to miscategorization of the sector receiving the funds [98]. For example, the Countdown financing estimates do not include contributions from key donors such as the Bill & Melinda Gates Foundation, and the data on how resources are allocated both within maternal, newborn and child health and between these areas and other public health activities are not standard and are insufficiently specific. Our failure to find a relationship between ODA and insecticide-treated nets for the prevention of malaria, for example, may be due to the fact that nets are largely funded from sources (like the Global Fund for HIV/AIDS, TB and Malaria) that are not specific to mothers and children. The analysis could also have been strengthened if we had been able to use a

moving average for our ODA measures, because of the high variability in ODA to these countries from year to year. Given our decision to use ODA disbursements two years prior to the more recent coverage measure, it was not possible for us to use a moving average because the first year for which Countdown estimates of ODA are available is 2003. This type of analysis will be possible once data sets from DHS and MICS surveys conducted since 2008 become available.

This paper contributes by highlighting the difficulties of conducting analyses of resource flows such as those called for recently by the Commission on Information and Accountability in Maternal, Newborn and Child Health [16]. Longitudinal data on both resources and covariates are needed, because cross-sectional associations cannot support inferences of causality, which in this area are likely to be complex and is poorly understood. The Countdown ODA data were available only for the years between 2003 and 2008, which was insufficient to support analyses of country-level change in this study. Other factors unable to be addressed adequately include that fact that ODA represents only a portion of the total resources available, and only a portion of those resources are actually used to support the delivery of interventions.

New levels of information will require stronger analyses and therefore greater investments in the development of high-quality data – not only on resources but also on other covariates and intervention coverage. In the meantime, the Countdown to 2015 program of cross-cutting research will continue to address these issues by testing the relationships in program areas where we believe more and better data are available on funding (both external and internal to the country) and coverage for specific

interventions, such as malaria and family planning. In-depth, longitudinal country studies are also likely to contribute to a better understanding of these relationships.

This analysis was also limited by the total sample size of 26 countries; more robust results may be obtained when data become available from additional DHS and MICS surveys or perhaps by expanding the analysis to all countries for which relevant data are available. Expanding the number of countries would also increase the generalizability of the results; the current results should be interpreted with caution because the countries included in the analysis have lower levels of GDP and female adult literacy than other Countdown countries in sub-Saharan Africa, as well as higher crude birth rates and total fertility rates.

Despite these limitations, this study represents a first step in unpacking the relationship between external assistance and intervention coverage, and in the broader research agenda of Countdown that aims to increase our understanding of the determinants of intervention coverage for MNCH. Further work is needed and is under way; the results will help guide donors and governments in their efforts to achieve high, sustained and equitable coverage with the interventions that can save the lives of women and children.

Paper 2: Metrics for Measuring Change in Population Coverage for MNCH Interventions: A Systematic Review

Abstract

Background

Changes in the proportions of women and children who need an intervention who actually receive it are central to monitoring progress toward the Millennium Development Goals and new goals that are now under discussion for the future. The aim of this review – the first on this topic – is to describe the metrics currently used to track changes in intervention coverage, and to assess the implications of the choice of metric for the results obtained and judgments about progress.

Methods and Findings

We conducted a systematic review of coverage change metrics for three intervention areas within maternal, newborn and child health, selected because they had the largest numbers of articles published in Pubmed: contraceptive prevalence, childhood vaccination and infant feeding. We searched Pubmed, the National Library of Medicine database, Embase, Popline and Scopus for English language articles published between 1990 and 2011 that reported coverage measurements at two or more time points using a quantified measure of coverage change, and conducted a hand search of the reference lists of all articles meeting the inclusion criteria. Among 9,166 unique articles identified, review by two independent researchers yielded 814 eligible articles after title review, 272 after abstract review, and 134 after review of the full paper (51 for contraceptive

prevalence, 57 for childhood vaccinations and 26 for infant feeding). Three-quarters of these studies were published between 2000-2011; 60% reported on data from high-income countries, with 37% using data collected in the United States. Forty-five percent of studies reported coverage measurements for more than two time points (range 2 to 20), but only 38% of these studies used data from more than two time points in their analysis. Most studies (83%) assessed coverage change by measuring absolute differences in percentage points between the first and last coverage measurements. Other methods included the calculation of the percentage increase or decrease over time (7%); use of regression with control for possible confounding or mediating variables (5%); and calculation of an average annual rate of change, with or without compounding (3%). We applied these methods to annual data on diphtheria-tetanus-pertussis (DTP3) vaccination coverage data for the period 1990 to 2010 in four countries (Botswana, Cambodia, Zimbabwe, Congo) obtained from WHO/UNICEF, and assessed the differences in results obtained by method and relative to the observed point estimates of coverage, both historically and when predicting future coverage rates. There were important differences by method, and based on whether all data points were included versus only the first and last data points. A comparison of predicted versus actual rates showed high concordance across methods for Botswana, where there was little change and a linear trend, moderately high concordance for Cambodia, with rapid linear change, and poor concordance for Congo and Zimbabwe where change was U-shaped with large and smaller interim low points, respectively.

Conclusion

The choice of a method for calculating coverage change has important implications for the results obtained and conclusions drawn, and must take into account whether the trend is linear (which is not always the case) and the objectives of the trend assessment. Consumers of coverage trend estimates must be aware of these implications and assess results critically before using them as the basis for decision making.

Introduction

Changes in national-level population coverage of maternal, newborn and child health interventions are key metrics in tracking progress towards meeting Millennium Development Goals (MDG) 4 and 5 [62]. These goals are focused on reducing child and maternal mortality by 66% and 75% respectively between the period of 2000 to 2015 [5]. Coverage change is defined as the annualized change in coverage as measured by nationally representative household surveys such as the Demographic and Health Surveys (DHS, http://www.measuredhs.com/) and Multiple Indicator Cluster Surveys (MICS, http://www.unicef.org/statistics/index_24302.html). From our research, we have determined that there are no established guidelines or formulas used in computing coverage change, therefore researchers have calculated change in several different ways, and the choice of methodology may have important implications for the results obtained.

This paper has two objectives: (1) to identify the different methods and metrics used for calculating annual changes in coverage for MNCH interventions by performing a systematic review of the literature; and (2) to assess the implications of the choice of method or metric for calculating coverage change by performing a data exercise to produce change estimates using each the methods identified.

Materials and Methods

Selection of Intervention Areas

We searched Pubmed to determine the MNCH intervention areas with the highest numbers of published articles. All coverage indicators tracked by the Countdown to 2015 for Maternal, Newborn and Child Survival were used as the starting point, and grouped

into areas to facilitate the search (See Appendix 1). For instance, three related countdown indicators (exclusive breastfeeding, complementary feeding and early initiation of breastfeeding) were combined into a general infant feeding area. Based on the search results, the three intervention areas selected for the review were contraceptive prevalence, child immunizations (a combination of measles, DPT3, Hib immunization indicators) and infant feeding. The review was limited to three intervention areas to avoid redundancy in the results.

Summary Measure and Inclusion Criteria

The summary measure of interest was a quantified measure of change in intervention coverage related to each area. Articles were included in the analysis if they were published in English since 1990. We used date of publication as the criterion because we expected that articles assessing coverage change would be likely to include historical data. Coverage measurements had to occur at two or more time points, and the article had to report on a quantified metric of coverage change. Data sources could be either population-based surveys or programmatic data. Articles not meeting eligibility requirements included those that only reported coverage change without quantification, articles that did not describe the methods used to assess change and review articles.

Databases

The search for articles focused on four databases: Pubmed [69], a free online portal that provides access to Medline, the National Library of Medicine database covering approximately 5400 journals with over 22 million citations and abstracts; Embase [70], a database with access to over 7600 journals and over 24 million citations covering Medline as well as over 5 million citations not included in Medline; Popline [71], the

largest database on family planning and reproductive health worldwide; and Scopus [72], the largest abstract and citation of literature worldwide with 47 million citations covering the scientific, technical, medical and social science fields. Of note, Pubmed, Embase and Scopus all provide citations from Medline, however these databases also independently provide access to unique resources. These databases were last searched on 30 November 2011.

Search Terms

An all-inclusive search was performed using vocabulary-controlled terms and specific commands for the respective databases. Keyword searches of titles, abstracts and the general body of the articles were performed. These searches were broad in nature, designed to capture all articles related to the search terms. Hand searching, i.e. a manual search of the reference lists of all eligible articles, was also conducted. Appendix 2 provides details on the search terms used in each of the databases.

Validation of the Search Strategy

The search strategy and terms were validated by reviewing search results to ensure that articles pre-identified as eligible for study inclusion were present in the search results. With the aid of a public health librarian, the search terms (Appendix 2) were continuously verified, and search terms were added, removed or refined as need by limiting or exploding searches until the pre-identified and other relevant articles were captured.

Data Selection

Two independent reviewers conducted the data selection process to ensure data accuracy and quality, in four steps. First, all articles found using our search terms were imported

into the Endnote reference management software [75] and duplicate articles were screened for and deleted. Second, the titles of the articles were screened for potential study inclusion and relevant titles were selected. Using a conservative approach, any article that was identified for inclusion by either reviewer was retained for further review. Third, the abstracts of all selected articles were reviewed and a further subset of eligible articles was created for potential data abstraction. Again, any abstract that was identified for inclusion by either reviewer was retained for further analysis. Finally, full manuscripts were obtained for all articles that were selected for data abstraction. Full text screening of the manuscripts was performed and data abstracted from eligible articles. Article selection occurred between October and November 2011.

We did not conduct an assessment of the risk of bias in the individual studies reviewed because our objective was to determine the metrics used to describe coverage changes, rather than to determine the actual rate of change in coverage for specific indicators.

Data Abstraction

Two independent reviewers performed the data abstraction. Differences were resolved by mutual agreement. The information abstracted from these articles included country of origin of the data, type of study and time period, type of survey data, the representativeness of the study, eligibility for inclusion, time allocation for coverage measurement, coverage change estimate methods and whether significance testing was employed. See Appendix 3 for the data abstraction form.

Assessment of effects of alternative metrics on coverage change results

We used annual estimates of DTP3 vaccine coverage available from WHO/UNICEF for the years 1990 through 2010 [99] to assess the implications of the choice of method or

metric for calculating coverage change. We systematically selected four countries with varying trajectories of DTP3 coverage levels during this period, and applied the formulas for each metric to estimate coverage change for the entire period, for the two periods 1990-99 and 2000-10. To assess the degree to which the estimation method affects the conclusions, the predicted coverage values (based on each method) were compared with the actually observed values for each country.

Results

Search results by intervention area

Figure 2 presents a flow chart of the search strategy and data abstraction process for the three intervention areas. The reviewed articles and the methods used for calculating coverage change are presented in appendices 4 – 6.

Contraceptive prevalence rate was defined by Countdown at the time of this review as the "percentage of women currently married or in union ages 15-49 that are using (or whose partner is using) a contraceptive method (either modern or traditional)". [100] A total of 3,214 articles that pertained to family planning, contraception, contraceptive devices and contained terms representing change in coverage were identified. After performing a title search, 3,048 articles were excluded, and 65 articles were selected for potential inclusion based on abstract review. Full manuscripts were obtained and 46 articles fulfilled the study inclusion criteria with an additional 5 articles identified via hand searching the references of the included articles.

Three Countdown indicators for childhood immunization coverage: measles (defined as the percentage of infants immunized with measles containing vaccine),

diphtheria/pertussis/tetanus (defined as the percentage of infants who received three doses of DTP vaccine) and *Haemophilus influenzae* type B (defined as the percentage of infants who received three doses of *Haemophilus influenzae* type B vaccine), were combined into one child immunization indicator theme. Using search terms for the immunization indicator (Appendix 2), we identified 2927 unique articles and based on the title search alone, we excluded 2478 articles. Upon reviewing abstracts, 109 articles were selected for potential inclusion and full manuscripts were obtained. A total of 59 articles were retained for analysis.

Countdown indicators related to breast feeding, i.e. exclusive breastfeeding (the percentage of infants ages 0 to 5 months who are exclusively breastfed), complementary feeding (the percentage of infants ages 6 to 9 months who are breastfed and receive complementary foods) and early initiation of breastfeeding (the percentage of newborns put to the breast within one hour of birth) were combined into a general infant feeding indicator theme. Using the search terms detailed in Appendix 2, we found 3025 unique articles. We excluded 2826 articles based on the title search; 98 articles were selected for full manuscript review based on their abstracts. A total of 25 articles were retained for analysis.

Characteristics of Included Studies

134 articles were included in this review. Their characteristics and the coverage change metrics used in the studies are summarized in Table 6.

The review findings indicate that there is no standardized approach for estimating or reporting on changes in intervention coverage. Six different methods were observed across the three intervention areas (Appendix 7): (1) Average Annual Rate of Change

(AAR); (2) Linear Regression (LR); (3) Absolute Change (AC); (4) Compound Annual Rate of Change (CAGR); (5) Percentage Change (PC); (6) Relative Change (RC). Table 7 summarizes the methods and their associated formulas. Assessing absolute changes in coverage levels was the most common method of computing coverage change and this method was used in 84% of the reviewed articles. We also found variations in how time periods were defined in the computation of coverage change. For example, assume that coverage rates are available at five distinct points in time: 1996, 2000, 2004, 2008, and 2012. Options include: 1) using all the time points to determine the average change per year; 2) using only the earliest and latest coverage measurements; and 3) using selected periods of interest. Both the methods used to compute change and the selection of time points may influence the calculated results on coverage change.

Based on these findings, we investigated further the impact of utilizing both the method of assessing change and time period definition in the determination of coverage change. In addition, we examined the role that varying coverage trajectories played on the coverage change. We achieved this by using calculating coverage change using immunization data from available from WHO/UNICEF for 4 countries with different coverage trajectories.

Examining differences in coverage change estimates by metric

The countries were purposively selected to reflect different patterns of DTP3 coverage change over the period from 1990 to 2010 (Figure 3). In Botswana, DTP3 coverage showed only minimal changes over the time period. In Cambodia there was a steady

linear increase. In Zimbabwe the trend was non-linear and showed small changes over time. In Congo (Brazzaville) there was also a non-linear pattern but with larger vacillations. Across the four countries, the range in point estimates for DTP3 coverage rates between 1990 and 2010 was 33% to 96% .

We calculated changes in DTP coverage using each of the six methods (Appendix 7). Table 8 presents results using all data from 1990 to 2010, and Table 9 presents the results using only data from 2000 through 2010. Note that all methods except LR use only two time points representing coverage rates at the beginning and end of the time period. LR incorporates all coverage rates during the time period in the assessment of coverage change.

Among the three methods that assessed annual change (CAGR, LR, AAR), CAGR produced the most extreme estimates. Coverage change estimates produced by LR and AAR do not differ greatly for the countries with linear trends; however, the less linear the trend, the more the difference in estimates, as shown for Congo and Zimbabwe.

In Botswana, the trend in coverage resembled a straight line with minimal changes over the entire time period. There was little variation when comparing the change estimates for the two time periods (1990 – 2010 vs. 2000 – 2010). Using all the time points between 1990 and 2010, the change estimates ranged from 0.15% to 0.21% per year. The change estimates produced by various methods in the latter decade were identical (0.10%) because there was little variability in the data.

Cambodia experienced an increase in coverage with an overall shape resembling the exponential function (Figure 3). The most linear increase occurred in 2000 and continued

through 2010. When focusing on the time period between 2000 and 2010, LR and AAR have similar results. The magnitude of change differs depending on the time frame and methods used with the annual estimates ranging from 3.70% to 4.54% and the summary estimates ranging from 33% to 142%.

Congo (Brazzaville) had a U-shaped curve for coverage trends. The coverage rates dropped in the decade between 1990 and 2000, and increased afterwards. Using the estimates that considered data from 1990 to 2010, there was less variation in the estimates of change with the annual estimates ranging from 0.55% to 1.48% and the summary estimates ranging from 11% to 14%. Use of LR is not appropriate for the data from 1990 through 2010, because it assumes a linear trend. However, when the rates were calculated using data from 2000 and beyond, where there was high variability in the data, the annual estimates ranged from 5.70% to 10.55% and the summary estimates ranged from 57% to 173%. The latter analysis of rates represents only the period where the rates were increasing and therefore the overall estimates are exaggerated. LR is a better fit for the data from 2000 and beyond. The dramatic change in the CAGR estimate (10.55%) reflects the fact that it uses only first and last year. This change is much more pronounced than in the first analysis that uses all the data, i.e. 1990 vs. 2010 coverage rates (0.65%).

Zimbabwe had coverage rates that decreased from 1990 through 2000 although it experienced some slight increases in coverage in the late 2000s. Using all the time points between 1990 and 2010, the annual change estimates were of similar magnitude ranging from -0.79% to -0.25% per year and the summary estimates for the entire period were the same (-0.5% vs. -0.6%). Using data from 2000 and beyond, a similar trend was observed

with from 0.2% to 0.5% per year and the summary estimates for the entire period were the same (4% vs. 5%). The direction of the estimate does change from negative to positive between the two time periods.

What method of computing annual rates best predicts future rates?

Using the calculated annualized change rates from the regression, CAGR and AAR methods, we predicted future rates in order to determine which methods would best predict rates given various patterns of coverage change. Using the coverage rates from 1990 & 2000, we projected forward 15 and 7 years later respectively. Table 10 presents the results.

The coverage rates are accurately predicted when there is little variation in coverage over time i.e. a linear trend, as is the case in Botswana. The method used when estimating coverage change under this scenario does not have an impact on the ability to predict future rates. However when there is a significant change in coverage, this may lead to an over or under estimation of the actual rates as is the case in countries Cambodia, Congo and Zimbabwe (Table 10). The more the variation, the larger the differences in estimated versus the actual rates. This can be seen clearly when the coverage rate from 1990 is used to predict 2005 coverage rates since the coverage rates vary more over time as compared to using the coverage rates from 2000 to predict future coverage values. In the latter scenario, the difference between the estimated rates and actual rates ranged from 0 to 13 percentage points versus 3 to 36 percentage points in the former.

Overall, the best predictions are for Botswana and Cambodia. In Botswana, all three methods agree since the amount of change is small therefore results from both additive (regression analyses, average annual rate) and multiplicative (CAGR) methods are the

same. For Cambodia, linear regression outperforms the other methods, especially during the 2000 to 2007 time period, because the trend is more linear. In Zimbabwe, though the predictions are similar from the various methods, they are an overestimate of the actual rate by about 10 to 20 percentage points. As expected, the worst prediction is for Congo due to the curvilinear shape of the data.

Discussion

This systematic review demonstrates that various methods and associated metrics are being used to estimate changes in intervention coverage for MNCH interventions, and that there can be wide variations in the results obtained depending upon which method is selected. The selection of time periods is also important, and constrains the appropriate metrics than can be used. For this exercise, we chose countries that represented a range of coverage rates and trends over time. There were important differences by method, and based on whether all data points were included versus only the first and last data points.

In countries with little change over time, for instance, Botswana, the method used to compute coverage change does not have major implications for the results due to the minimal changes over time in the coverage rates. However, we have demonstrated that in countries where the coverage rate is changing dramatically, the method used to compute coverage change may have an impact on the conclusions drawn. In Cambodia, the magnitude of the annual estimate ranged from 1.65% to 4.54% depending on the method and time period used to compute coverage change and this range was even more extreme in the Congo with the annual change estimate ranging from 0.55% to 10.55%. Finally, the

direction of change can be positive or negative depending on the time frame used as seen in the case of Zimbabwe.

All three methods of assessing annual change (regression, CAGR and AAR) assume there is monotonic change, i.e. change in only a positive or a negative direction. If the data support additive change (equal increase or decrease per unit time), methods based on linear assumption, such as average annual rate or linear regression model are the best methods to use to summarize change. On the other hand, if the data support multiplicative change, (where rate of change increases or decreases by the same amount over time), the compound annual change rate is the best method. These methods are not appropriate when the trend is not monotonic and it changes its direction as in the case of Congo. Under this condition, the overall time should be split into 2 or more periods, where within each time period the change is monotonic and the appropriate method for summarizing the change can be used.

Several considerations need to be taken into account when selecting a coverage change metric. First, investigators must consider the underlying pattern of coverage change. If the trend is non-linear, the investigator needs to decide which data points to use. Using all available data points would lead to an incorrect assessment of the change in coverage. Examining the change within time periods characterized by monotonic change provides a clearer summary of the trend and a better prediction tool for future coverage.

Second, investigators must consider the objectives of the analysis, and this may constrain the choice of metric. If policymakers are interested in the overall performance of a program over time, an absolute measure of change between two time points such as the

first and last survey may provide an adequate measure. However, if the investigator wants to perform a comparative analysis across settings for which data are available only for selected and different years, an annual measure of change may be preferred.

Third, investigators must consider the audience for their results. Donors or program managers may only be interested in determining whether coverage has increased or decreased over time. More sophisticated measures of computing coverage change may not be needed since the primary interest is in the absolute change over time not the rate of change.

Fourth, investigators must consider the intended use of the results. If the change metrics are being used as inputs to models that will predict future data trends, then it is important to consider all the above mentioned points especially the underlying shape of the data and how time will be allocated in the calculation. The MNCH community is increasingly using models like the Lives Saved Tool [101] that estimate the number of deaths that have been averted due to the scale-up of interventions. This requires that non-linear patterns be reflected in the results; not doing so would result in over- or under-estimates of the lives saved.

This review and analysis has limitations. First, there may be biases in the set of articles we identified reporting on coverage change, with studies using specific metrics less likely to be submitted or accepted for publication. This bias would not vitiate our primary finding, which is that a variety of metrics for computing coverage change are currently in use which produce different results. Second, there is almost certainly selective reporting bias, with authors electing to report on a single metric of coverage change although their data could support use of several. This reinforces our recommendation that reporting

standards be adopted to increase comparability of coverage change estimates across studies and over time. Third, we selected indicator themes based on those with the highest number of articles in Pubmed; and conducted the data exercise using DTP3 because of data availability. It is possible that the metrics reported for these themes and the patterns described for DTP3 are not consistent with those for other indicator themes or interventions.

Conclusions

The choice of metrics to assess changes in coverage for MNCH interventions can have important effects on the results. Comparisons of progress in achieving targets for intervention coverage should be based on the same metric. In addition, investigators need to justify the choice of their coverage change metric and address the potential impact of that choice on their results. Those who use coverage change results must be alert to the metrics that are being used, and actively question whether the choice is appropriate and how it may affect the results and their interpretation.

Paper 3: Factors associated with the utilization of maternal health interventions among women with varying socioeconomic status: An analysis of the 2008 Nigeria Demographic Health Survey (NDHS) data.

Abstract

Background

Levels of health and socioeconomic indicators in Nigeria remain lower than optimal, despite increases in official development assistance for maternal health and ongoing health reforms including the implementation of national policies aimed to increase equitable access to health services. SES is known to be a positive predictor of maternal health utilization, however this relationship can be modified in the presence of increased financing, maternal health education and pro-poor health policies. The aim of this study is to describe further the relationship between maternal health utilization and socioeconomic status among Nigerian women.

Methods and Findings

We reanalyzed the 2008 Nigeria DHS (NDHS), a nationally-representative survey, to determine predictors of maternal health utilization among poor and rich women. Using wealth quintiles from NDHS, the top 2 wealth quintiles of women were considered rich and the bottom 2 wealth quintiles were considered poor. Maternal health utilization was defined as either the use of a skilled birth attendant at delivery or having 4 or more antenatal care visits. For each dependent variable, separate analyses were conducted among poor and rich women to identify the individual characteristics that predict

maternal health utilization. Independent variables included current age, age at first birth, parity, maternal education, ethnicity, region of residence, religion, marital status, locality and current maternal employment.

Across all wealth categories, higher levels of maternal health education and urban living were significantly associated with the use of skilled birth attendants and 4 or more ANC visits. Maternal employment was significantly associated with antenatal care visits for all mothers, however only poor mothers had associations between employment and the use of a skilled birth attendant. Hausa ethnicity was significantly associated with non-use of maternal health services across categories. Among wealthier women, being of older age, a Muslim and married or cohabitating were all associated with the utilization of maternal health services.

Conclusion

The findings of this analysis are important to facilitate the appropriate targeting of health interventions, ensuring efficiency in the use of funds for maternal health. Maternal education and employment are strong predictors of maternal health utilization, therefore increasing investments in the health sector should occur in conjunction with continued investments in female education, Regardless of socioeconomic status, rural dwellers and women of Hausa ethnic origin are less likely to use maternal health services, and particular effort is needed to increase utilization among these women. Understanding these dynamics in the delivery of health interventions in Nigeria is important to accelerate progress towards meeting national and global public health goals.

Background

Nigeria is a lower middle income country situated in West Africa with a population of over 160 million individuals.[102] Sixty-three percent of the Nigerian population live below the poverty line, with 51% and 69% in urban and rural areas respectively.[103] The current Gini index of 48.4, a measure of income distribution, shows that there is substantial inequality in the distribution of income; the richest 20% hold 54% of the income while the poorest 20% hold only 4.5% of the income.[104] Poverty is linked to poor health outcomes and is a major barrier to human development.[40] It is also a major contributor to child and maternal mortality due to the inability to seek proper care, receive quality care and access health services.[41, 42] Consequently, in Nigeria, health status and outcomes differ across wealth quintiles with women in the top quintiles accessing more health services and experiencing better maternal and infant health outcomes compared to their poorer counterparts.[105] Regional differences also exist in the uptake of health services.[106] Nigeria has recognized poverty as a significant barrier to improving the health status of the nation and has implemented several initiatives to address the link between poverty and health.[107]

In 1988, in response to the Alma Ata Declaration [108], Nigeria established a primary health care policy (PHC) aimed at improving the health status of all Nigerians by 2000.[109] Due to the lack of progress towards this goal, the policy was revised in 2004 and accompanied by comprehensive health sector reform.[110] The Health Sector Reform Program (HSRP) (2004-2007) introduced health policies and legislation in order

to actualize the goal of improving the health sector.[107] Included among these were the National Health Policy review, the National Health Bill, the National Health Insurance Scheme and additional efforts towards improving disease control programs and quality of health care service delivery.[107] However, recent health and socioeconomic indicators show that major improvement is still needed to achieve the goals of the HSRP. As of 2008, the maternal mortality ratio in Nigeria was 550 deaths per 100,000 live births, total fertility rate was 6 births per woman, the infant mortality rate was 86 deaths per 1,000 live births, the adult female literacy rate was 50% and life expectancy at birth was 50 years for both males and females.[105]

As a country with high maternal and child mortality rates, Nigeria receives official development assistance to improve the coverage of key MNCH interventions.[21] Increased population coverage is important to attain not only national but also global health goals such as the Millennium Development Goals (MDGs). Of particular interest are MDGs 4 and 5, i.e. to reduce the under-five mortality rate by two-thirds and the maternal mortality ratio by three-quarters between 1990 and 2015, respectively.[111] Since 2003, aid flows to maternal, newborn and child health have steadily increased, although the rate of increase has slowed [7]. Nigeria experienced over an increase of over 1600% in aid flows to maternal health between 2003 and 2006: from US $430 per live birth to US $7,480 per live birth.[17] During the same time period, the National Health Insurance Scheme was officially launched[112] and the amount of governmental spending on health as a percentage of the total health expenditure increased from 22% in

2003 to 41% in 2008.[105] Despite the increase in funding for health, however, progress towards achieving MDGs 4 and 5 remains less than optimal.[14]

Disparities between socioeconomic status (SES) and maternal health service utilization have been well described in the literature.[113-118] Increasing socioeconomic status is linked with increasing use of maternal health services.[113, 115] Other studies have shown that increased financing, improvements in maternal education and pro-poor policies are successful in modifying the relationship between SES and use of maternal health services.[118-120] A study using data from 45 developing countries found that increasing health spending coupled with redistributive health policies increased the use of maternal health services among the poor.[119] In Bangladesh, maternal education was found to be an important predictor of health service utilization, and its effects were not dependent on socioeconomic status or access to healthcare services.[121] McTavish et al. conducted a multi-country analysis utilizing data on sub-Saharan African countries from the 2002-2003 World Health Survey and found that countries with higher maternal literacy had weaker associations between SES and maternal health care service use compared to countries with lower levels of maternal literacy.[122] In Brazil, where a universal health care policy promotes equitable distribution of health services, no association was found between SES and four or more antenatal care visits.[120] However, the evidence is not consistent, with additional findings showing that even in the presence of pro-poor policies, the relationship between SES and utilization of maternal health services still exists.[123] In addition to SES, other factors such as individual and household characteristics like age at birth, parity, locality, access to care, social norms,

the political economy and the environment also influence the utilization of maternal health interventions.[48, 124-127]

Beyond socioeconomic status, the Andersen model of health care utilization [128] describes three main elements that contribute to health service utilization: predisposing factors such as socio-demographic characteristics, enabling factors such as the ability to obtain care, and the perceived need to use health services. This study focuses on sociodemographic characteristics associated with maternal health utilization, using available data from the 2008 Nigeria Demographic and Health Survey.[76] Data on enabling factors and the perceived need to use health services were not available in the data set.

Study Justification

External health financing for maternal health has been increasing steadily in Nigeria, along with governmental investments in health.[107, 109, 110] The impact of increasing financing for maternal health and the presence of policies on the relationship between women's socioeconomic status (SES) and utilization of maternal health services in Nigeria has not been described. This analysis seeks to describe factors that are associated with the use of maternal health interventions among women of varying socioeconomic status. This paper will contribute to the body of knowledge on factors affecting the uptake and utilization of maternal health services in the face of increasing ODA and appropriate health policies. The results of this study will allow policymakers and other stakeholders to better understand the dynamics between SES, health financing and

maternal health services utilization and allow for increased efficiency of public health programs by better targeting of resources.

Methods

Data from the 2008 Nigeria Demographic Health Survey (DHS)[76] are used in this analysis. This paper analyzes a subset of the data from the previous analysis on the impact of ODA on the coverage of MNCH interventions, focusing on Nigeria, the country with the highest amount of ODA to maternal health. This is a nationally representative household survey that used a multistage sampling technique. A total of 888 clusters consisting of 286 urban and 602 rural areas are represented. A final cluster size of 886 was used due to inaccessibility of 2 clusters. The clusters in each state were not proportional to their total population, and urban areas were over-sampled to obtain information for the total urban population. These clusters resulted in a sample of 36,800 households within all the six geopolitical zones in Nigeria. Three questionnaires were used in this survey: the household questionnaire collected information on the household listing including age, sex, education, residence, household characteristics including drinking water source, sanitation, household assets and nutritional status of women and children; the women's questionnaire collected information on socio-demographic characteristics, reproductive behavior, contraception, care before, during and after delivery, infant feeding, children's health; the men's questionnaire collected information on socio-demographic characteristics, reproduction, contraceptive knowledge and use, employment and other health issues. The questionnaires were administered to all women between the ages of 15 and 49 who lived or visited the households the night prior to the

survey. Men between the ages of 15 and 59 in every other household who lived or visited the night prior to the survey were also interviewed. The final sample of eligible women and men interviewed was 33,385 and 15,486 respectively. Of the 33,385 women, 15,357 did not bear children in the last 5 years and were excluded. The analyses were limited to women in the top 2 wealth quintiles (labeled 'rich', n=5530) and women in the bottom 2 wealth quintiles (labeled 'poor', n=8992). A final sample of 14, 522 women was included in the analyses.

Outcome Variables

Maternal health service utilization was the dependent variable in this study and was defined as either (1) the use of a skilled birth attendant or (2) having 4 or more antenatal care visits. These two indicators are used to monitor progress towards maternal health goals (MDG 5).[79] Both dependent variables are defined as indicator variables with use of service coded as 1 and non-use coded as 0. Separate analyses were conducted for each dependent variable.

Explanatory Variables

Socioeconomic and demographic predictors of maternal health service utilization were included in this analysis. The variables were: maternal age (6 categories); age at first birth (5 categories); parity (1 to 4 or more deliveries); maternal educational level (none, primary level or secondary or higher level); current maternal employment (yes or no); ethnicity (Ibo, Yoruba, Hausa and other);, religion (Christian, Muslim and other); locality (rural or urban residence); and region (North or South).

Statistical Analysis

A chi-squared test was used to test for associations between the dependent and independent variables. Bivariate and multivariate models for logistic regression were utilized for predicting the outcome of a categorical variable (the use of 4+ ANC visits or skilled birth attendant, yes/no) based on one or more predictor variables. All variables that had significant associations at alpha level 0.05 were included in the multivariate analyses. The odds ratio with 95% confidence interval are presented in the results. P values of <0.05 were considered statistically significant in the multivariate analyses. The analysis accounted for the survey sampling design by using sampling weights provided by DHS. The statistical software program used was Stata 10.[129]

Results

Sample Characteristics

Table 11 presents the background characteristics of the women in the two income groups. The majority of women in both groups were in 25-39 age group, experienced their first birth at less than 25 years of age, had 4 or more children and were married or cohabitating. Poor and the rich women were significantly different ($p<0.000$) for all categories. Notably, 72% of the poor women had no education compared to 15% of the rich women; 68% of the poor women were Muslims while 60% of rich women were Christians; the majority of poor women lived in the North, 86%, compared to 40% of rich women residing in the North; 61% of rich women were urban dwellers compared to only

6% of poor women and Hausa's constituted 51% of the poor women and only 17% of rich women.

Table 12 presents the association between the dependent and explanatory variables using a chi-squared test among rich and poor women. Maternal education was not associated with having 4 or more antenatal care visits ($p=0.269$) or the use of skilled birth attendants in either rich or poor women ($p=0.645$). All other variables were significantly associated, $p<0.000$.

Tables 13a & 13b present the results of the univariate regression analyses, odd ratios with their 95% confidence intervals.

4+ ANC Visits- Poor Women

Older age at first birth was also significantly associated with ANC visits; women who experienced their first births between the ages of 20 and 29 were approximately 1.4 times more likely to have 4 or more ANC visits than those with first births in the less than 15 years of age category. Women with at least a primary education were 2 times more likely to have 4+ ANC visits compared to women without education. Rural women were 60% less likely to have 4 or more ANC visits. Compared to women of Igbo ethnicity, Yoruba women were 2.7 times more likely to have 4+ ANC visits whereas Hausa women were 0.5 times less likely. Employed women were 1.3 times more likely to utilize ANC services.

4+ ANC Visits- Rich Women

Older age was significantly associated with ANC visits with the highest odds of 4 or more ANC visits in the 40 to 44 age category. Older age at first birth was also significantly associated, women who experienced their first births between the ages of 25 and 29 were 1.4 times more likely to have 4 or more ANC visits than those with first births in the less than 15 years of age category. Urban dwellers, maternal employment, married women, women with at least a primary education Christians were also more likely to have 4+ ANC visit. Muslim wealthy women were 1.7 times more likely to use ANC services.

Skilled Birth Attendant Use- Poor Women

Women with at least a primary education and those with a secondary education were 2.1 and 3.4 times more likely than uneducated women to use skilled birth attendants. Urban dwellers, and employed women were also more likely to have utilized a skilled birth attendant. Hausa women were 83% less likely than Igbo women to utilize the services of skilled birth attendants.

Skilled Birth Attendant Use- Rich Women

Married women, urban dwellers, and increasing educational levels were all significantly associated with the use of a skilled birth attendant. Muslims were more likely to use SBAs compared to Christian women with other religious background. Hausa women were 94% less likely than Igbo women to utilize the services of skilled birth attendants.

Tables 14a & 14b present the results of the multivariable logistic regression for each dependent variable.

4 or more antenatal care visits

After controlling for socioeconomic and demographic variables, common predictors of four or more ANC visits that were present in both poor and rich women were 1) higher levels of maternal education (women with secondary or higher level education were at least 2 times more likely to have four or more ANC visits compared to women without education), 2) rural residence (women living in rural areas were at least 40% less likely than urban dwellers to have 4+ ANC visits), and 3) maternal employment. Among rich women, Hausa women were less likely to have 4 or more ANC visits compared to Igbo women; being married or Muslim was associated with 4 or more ANC visits.

The use of a skilled birth attendant

Among poor and rich women, women with a secondary or higher level education were at least 3 times more likely than women without education to use a skilled birth attendant. Urban dwellers were also more likely than rural dwellers to use a skilled birth attendant at delivery. Among rich women, those that were more likely to use a skilled birth attendant were of Ibo ethnic origin, Muslim and married. Hausa women were less likely to use a skilled birth attendant regardless of socioeconomic status.

Discussion

This study sought to describe factors that were associated with the utilization of maternal health services among women of varying socioeconomic status. Among both poor and rich women, higher levels of maternal education and urban living were significantly associated with both the use of a skilled birth attendant and having completed 4 or more ANC visits. Maternal employment was significantly associated with antenatal care visits for all mothers, however only poor mothers had associations between employment and the use of a skilled birth attendant. Hausa ethnicity was significantly associated with non-use of maternal health services across all categories. Among wealthier women, being a Muslim and married or cohabitating were all associated with the utilization of maternal health services.

The findings of this analysis are aligned with other studies that have shown that maternal education and urban living are important predictors of use of maternal health services. Singh et al. found that married poor women in rural areas were less likely to utilize maternal health services than their unmarried, less poor or urban counterparts [117]. Similarly, Fotso et al found that poor women with low educational levels were less likely to utilize maternal health services than their less poor, more educated counterparts [130], and Kitui et al. found that urbanicity, higher educational levels, wealth were strongly associated with a health facility delivery [131]. Among studies conducted in Nigeria, education has also been found to be a significant predictor of maternal health utilization [48, 124, 126, 132, 133] These studies were both based on data that were nationally representative as well as some that were community-based.

Regional differences in health outcomes are well documented in Nigeria [106, 134, 135] although there were no significant associations between region of residence and the outcomes of interest in this analysis. However, the regional units (north vs. south) differed from the previous analyses where a finer breakdown of regions was used. In addition, rural dwellers and women of Hausa ethnic origin were less likely to use maternal health services regardless of socioeconomic status, suggesting that particular effort is needed to increase utilization among these women.

Female education has been linked to improved maternal health outcomes [136-138] and is widely recommended as a successful long term approach to improving maternal health [139-141]. Nigeria has a history of robust education investments from The National Policy on Education enacted in 1977 [142] to adopting the World Declaration on Education for All [142]. Additional reforms in the education sector were introduced in 1999.[143] The Universal Basic Education Programme was focused on increasing access to education as well as ensuring quality education from primary through secondary level education.[143] Furthermore in 2004, additional social reforms that recognized the link between poverty and lack of basic services such as healthcare and education were implemented, providing additional investments in education.[144] However current estimates show that only 44.6% of women have attained secondary or higher level of education with variations by region, area of residence and wealth quintiles.[76] The Northern region has the lowest amount of women attaining secondary level education or higher, 14% compared to the South with 70%; 67% of urban dwellers compared to 32% of rural dwellers and 84% of individuals in the highest wealth index compared to 8% in

the lowest wealth index.[76] Our findings indicate that the current approaches to improve health, especially among the poor, may not be effective. These findings of this analysis are important to facilitate the appropriate targeting of health interventions, ensuring efficiency in the use of funds for maternal health. Maternal education and employment are strong predictors of maternal health utilization and with increasing investments in the health sector and ongoing investments in education, additional research is needed on appropriate strategies to ensure that the most vulnerable individuals are reached and that the goal of improving maternal health outcomes are met.

This study of the predictors of maternal health service utilization had several limitations. Only the association of individual level predictors were examined in this analysis, although broader factors can also play an important role. The Andersen model[128] describes three main elements that contribute to health service utilization: predisposing factors such as socio-demographic characteristics, enabling factors such as the ability to obtain care, and the perceived need to use health services. Therefore the results of this study should be interpreted within the context of individual level predictors only. Demographic health survey (DHS) data were used for this analysis. Although a robust source of data, this survey is not exhaustive and data on maternal health behavior are limited. Variables such as the availability of health services or distance to health facilities were not available for analysis despite their importance in predicting the use of maternal health services.[145] This study only provided a snapshot of the current predictors of maternal health utilization and trends over time in this relationship were not investigated.

In addition, the quality of care received is not reflected in the results of this analysis, and the variables used are indicative of service provision only.

Conclusion

To increase the coverage of maternal health interventions in Nigeria, it is important to understand the dynamics between socioeconomic status and the uptake of interventions. This study has provided additional insights on this relationship that will aid policymakers and other stakeholders to better understand the dynamics between SES and maternal health services utilization and allow for increased efficiency of public health programs by better targeting of resources.

Overall Conclusion

The overall goal of increasing coverage of maternal and child health interventions is to improve health outcomes, specifically child and maternal mortality. However progress towards MDG 4 & 5, although improving is still less than optimal. There are recognized challenges in improving MNCH as the pathway from increased financing to improved health outcomes is complex. Several factors play important roles, including individual and household behaviors, the strength of the health system, the political economy, financing and national policies. This paper attempts to understand this relationship by examining different pieces of this pathway both within and across countries.

First, the impact of ODA on the uptake of MNCH interventions, controlling for other factors, was examined. Among the six indicators analyzed, we found that ODA to child health was associated with ORT levels and exclusive breastfeeding and ODA to maternal and newborn health was associated with the use of a skilled birth attendant at delivery. No other significant, positive associations were found. Lack of associations could be due to a variety of reasons including the analytical methods, the coverage change methodology, and the measure of ODA used. This analysis represents an important attempt to unravel this complex relationship and provides areas for future research including the long term impact of ODA on coverage of MNCH interventions. This will require longitudinal data on the amounts ODA to a particular intervention or group of interventions and coverage rates over time taking into account country characteristics, including domestic expenditures on MNCH. In addition, there is a need to standardize the

calculation of coverage change measurement in order to ensure that researchers are consistent in their analyses.

Second, the systematic review of coverage change methodologies used in the current body of literature found that the method of computing change and associated metrics are important in coverage change estimates. Estimates of coverage change differ based upon which method is selected. The trend of coverage rates within a country also matter when computing coverage change. Countries with unstable rates have different change estimates depending on the methods used. In countries with stable coverage rates over time, the method used to compute change was less important. Based on the findings, we strongly advocate for standardized methods for computing coverage change to ensure that results are comparable and interpreted in the same manner across different studies.

Last, we found that there were important similarities and differences in the predictors of maternal health utilization among poor and rich women in Nigeria. Maternal education and employment are strong predictors of maternal health utilization regardless of socioeconomic status; therefore increasing investments in the health sector should occur in conjunction with investments in education and the economy. Similarly, rural dwellers and women of Hausa ethnic origin are less likely to use maternal health services, and particular effort is therefore needed to increase utilization among these women.

The factors associated with maternal health utilization in Nigeria are presented and the results are aligned with previous research performed in the country. Strategies that have

been successful in improving maternal health in other settings include strengthening community based approaches[146], improving female education [136, 138], pro-poor policies to increase access and utilization of health services [43] and strengthening monitoring and evaluation to determine the progress or lack thereof of maternal health programs[147]. Through its various reform programs [107, 109, 110, 112], Nigeria has implemented these strategies. However, the less than optimal findings suggest that there are barriers to the effective implementation of these programs. This is worrisome considering the vast amount of financial and other resources being committed to the country. Additional research on the health system dynamics that impact the uptake of MNCH interventions is important to ensure that those in need are appropriately targeted. These findings will aid policymakers and country leadership in developing appropriate maternal health programs in Nigeria and should accelerate the progress towards meeting national and global public health goals.

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Tables

Table 1: Type and year of household surveys and year of ODA (Official Development Assistance) estimates used in the analysis

Type and year of household surveys and year of ODA estimates

	Country	ODA	Most Recent Survey		Earlier Survey	
		Year	Year	Source	Year	Source
1	Benin	2004	2006	DHS	2001	DHS
2	Burkina Faso	2004	2006	MICS	2003	DHS
3	Burundi	2003	2005	MICS	2000	MICS
4	Cameroon	2004	2006	MICS	2000	MICS
5	Chad	2003	2004	DHS	2000	MICS
6	Congo, DR	2005	2007	DHS	2001	MICS
7	Côte d'Ivoire	2004	2006	MICS	2000	MICS
8	Ethiopia	2003	2005	DHS	2000	DHS
9	Gambia	2003	2005	MICS	2000	MICS
10	Ghana	2006	2008	DHS	2003	DHS
11	Guinea-Bissau	2004	2006	MICS	2000	MICS
12	Kenya	2006	2008	DHS	2003	DHS
13	Lesotho	2003	2004	DHS	2000	MICS
14	Madagascar	2006	2008	DHS	2003	DHS
15	Malawi	2003	2004	DHS	2000	DHS
16	Mali	2004	2006	DHS	2001	DHS
17	Mauritania	2005	2007	MICS	2001	DHS
18	Niger	2004	2006	DHS	2000	MICS
19	Nigeria	2006	2008	DHS	2003	DHS
20	Rwanda	2003	2005	DHS	2000	DHS
21	Senegal	2003	2005	DHS	2000	MICS
22	Sierra Leone	2003	2005	MICS	2000	MICS

Type and year of household surveys and year of ODA estimates

23	Swaziland	2004	2006	DHS	2000	MICS
24	Togo	2004	2006	MICS	2000	MICS
25	Uganda	2004	2006	DHS	2000	DHS
26	Zambia	2005	2007	DHS	2001	DHS

Table 2: Selected country characteristics in sub-Saharan African countries included (N = 26) and excluded (N = 16) in the analysis about two years prior to most recent measurement of intervention coverage, using p-values for t-test two-group mean comparison.

	Included Countries, Mean ± SD	n	Excluded Countries, Mean ± SD	n	p- value
Characteristics Not included in models					
Under five mortality rate per 1000 live births	168.15 ± 45.92	26	146.94 ± 57.22	16	0.193
Maternal mortality rate per 100,000 live births	946.15 ± 399.85	26	781.88 ± 339.30	16	0.179
Total fertility rate, births per woman	5.27 ± 0.91	26	4.66 ± 1.14	16	0.063
Crude birth rate per 1000 people	39.48 ± 5.63	26	35.08 ± 6.74	16	0.027
Adult literacy rate, females aged 15 and over[1]	49.36 ± 22.46	26	63.90 ± 21.15	13	0.060
Mean years of education[2]	4.12 ± 1.77	25	N/A		
Characteristics Included in models					
Governance Indicators for political stability and absence of violence	-0.62 ± 0.90	26	-1.04 ± 1.04	16	0.1753
Health worker density per 1000 population	1.01 ± 1.23	26	1.41 ± 1.60	16	0.373
HIV prevalence among adults 15-49,%[3]	5.51 ± 6.96	24	6.89 ± 7.71	16	0.568
Out of pocket expenditure as a percentage of total expenditure on health[4]	43.22 ± 19.33	26	41.27 ± 20.44	15	0.762
Gross domestic product per capita (Current International Rate)[5]	1310.64 ± 859.78	26	6141.23 ± 8532.16	14	0.006

[1]Adult literacy is reported here because data are available for all countries. Mean years of education is used in the analysis; this variable was computed from the raw data and is only available for the countries that were included. Countries missing information: Democratic Republic of Congo, Djibouti, Somalia

[2] Country missing information: Mauritania

[3] Countries missing HIV prevalence data: Democratic Republic of Congo, Ethiopia

[4]Country missing OOP data: Somalia

[5]Countries missing GDP data: Somalia, Zimbabwe

Table 3a: Estimated linear correlation coefficient for the relationships between selected country characteristics and the levels of intervention coverage, 26 countries in sub-Saharan Africa.

		Antenatal Care	Skilled Birth Attendant	Insecticide Treated Nets	Exclusive Breastfeeding	Oral Rehydration Therapy	Careseeking for Pneumonia
Maternal Education	r	0.342	0.289	0.172	0.149	0.336	0.513
	p value	0.094	0.161	0.432	0.509	0.100	***0.009***
Mean years of education as reported by female respondent	n	25	25	23	22	25	25
Governance	r	0.238	0.305	0.558	-0.05	0.389	0.208
	p value	0.242	0.130	***0.006***	0.819	***0.050***	0.308
Governance Indicators for political stability and absence of violence	n	26	26	23	23	26	26
Health Worker Density	r	0.094	0.351	-0.118	-0.032	0.25	0.351
	p value	0.648	0.078	0.593	0.885	0.218	*0.078*
Density per 1000 population	n	26	26	23	23	26	26
HIV Prevalence	r	0.232	0.334	-0.241	0.161	0.544	0.366
	p value	0.286	0.119	0.306	0.497	***0.007***	0.086
Prevalence among adults 15-49,%	n	23	23	20	20	23	23
Out of Pocket Expenditure	r	-0.319	0.017	-0.228	-0.498	-0.386	-0.359
	p value	0.112	0.936	0.296	***0.016***	***0.051***	0.071
Expenditure as a percentage of total expenditure on health	n	26	26	23	23	26	26
Gross Domestic Product	r	0.165	0.451	-0.151	-0.173	0.28	0.23
	p value	0.421	***0.021***	0.493	0.430	0.167	0.257
GDP per capita (Current International Rate)	n	26	26	23	23	26	26

Table 3b: Estimated linear correlation coefficient for the relationships between selected country characteristics and the annualized change in intervention coverage, 26 countries in sub-Saharan Africa.

		Antenatal Care	Skilled Birth Attendant	Insecticide Treated Nets	Exclusive Breastfeeding	Oral Rehydration Therapy	Careseeking for Pneumonia
Maternal Education	r	-0.063	-0.012	0.166	0.155	0.079	0.143
Mean years of education as reported by female respondent	p value	0.765	0.953	0.538	0.515	0.708	0.496
	n	25	25	16	20	25	25
Governance	r	0.206	-0.085	0.486	0.062	0.258	-0.194
Governance Indicators for political stability and absence of violence	p value	0.312	0.687	*0.056*	0.795	0.213	0.354
	n	26	25	16	20	25	25
Health Worker Density	r	-0.193	-0.033	-0.209	0.073	0.094	-0.148
Density per 1000 population	p value	0.346	0.876	0.438	0.761	0.656	0.480
	n	26	25	16	20	25	25
HIV Prevalence	r	-0.143	-0.02	-0.155	0.456	0.029	0.191
Prevalence among adults 15-49,%	p value	0.506	0.927	0.582	***0.050***	0.893	0.371
	n	24	24	15	19	24	24
Out of Pocket Expenditure	r	-0.234	0.069	-0.135	-0.016	-0.446	0.070
Expenditure as a percentage of total expenditure on health	p value	0.250	0.745	0.617	0.948	***0.026***	0.738
	n	26	25	16	20	25	25
Gross Domestic Product	r	-0.162	-0.155	-0.239	-0.01	0.094	-0.027
GDP per capita (Current International Rate)	p value	0.430	0.460	0.373	0.965	0.656	0.898
	n	26	24	16	20	25	25

Table 4: Results of meta-regression models estimating the effect of ODA on levels of intervention coverage for selected interventions, 26 countries in sub-Saharan Africa.

Coverage Level	Model 1[1]	Model 2[2]*				Model 3[3]*				
	adj. R^2	Beta†	95% CI‡	p-value	adj. R^2	Beta†	95% CI‡	p-value	adj. R^2	Included Covariates
Antenatal Care	81.76%	0.17	-0.18, 0.52	0.324	81.79%	0.12	-0.22, 0.47	0.459	85.98%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence
Skilled Attendant at Birth	84.82%	0.09	0.19, 0.37	0.525	84.39%	0.09	0.19, 0.37	0.525	84.39%	Baseline Coverage and ODA (same as the Model 2)
Use of Insecticide Treated Bednets	52.85%	0.07	-0.93, 1.09	0.878	49.27%	-0.13	-1.31, 1.06	0.813	56.97%	Baseline Coverage, ODA, Maternal Education, Governance, HW density
Exclusive Breastfeeding	74.21%	0.79	-0.12, 1.72	0.086	77.46%	0.79	-0.12, 1.72	0.086	77.46%	Baseline Coverage and ODA (same as the Model 2)
Oral Rehydration Therapy for diarrhea	-4.23%	1.19	0.39, 1.99	0.005	24.97%	1.10	0.00, 2.20	0.05	58.69%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence, OOP and GDP
Careseeking for Pneumonia	78.02%	0.37	-0.29, 1.04	0.257	78.32%	0.51	-0.32, 1.34	0.205	81.31%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence, OOP and GDP

[1] - the model only includes the baseline coverage rate as the predictor

[2] - the model includes baseline coverage rate and ODA as predictors

[3] - most optimal model associated with largest adjusted R-squared for the given set of predictors

* - presented are beta coefficients, 95%CI and p-values for ODA

† - beta coefficient represents the estimated percentage point difference in coverage for countries that differ by $1 in ODA

‡ - 95%Confidence Interval for the beta coefficient

Table 5: Results of meta-regression models estimating the effect of ODA on annualized change in intervention coverage for selected interventions, 26 countries in sub-Saharan Africa.

Annualized change in coverage	Model 1[1]				Model 2[2]*				Model 3[3]*	
	adj. R^2	Beta†	95% CI‡	p-value	adj. R^2	Beta†	95%CI‡	p-value	adj. R^2	Included Covariates
Antenatal Care	-2.67%	0.03	-0.03, 0.10	0.277	-1.46%	0.04	-0.02, 0.10	0.175	10.23%	Baseline Coverage, ODA, Maternal Education, Governance
Skilled Attendant at Birth	-7.47%	0.04	-0.01, 0.09	0.095	7.30%	0.04	-0.01, 0.09	0.095	7.30%	Baseline Coverage and ODA (same as Model 2)
Use of Insecticide Treated Bednets	22.23%	0.02	-0.17, 0.21	0.793	16.07%	-0.09	-0.42, 0.24	0.522	42.29%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence, OOP and GDP
Exclusive Breastfeeding	-6.72%	0.13	-0.06, 0.32	0.159	0.19%	0.12	-0.11, 0.35	0.275	16.64%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence
Oral Rehydration Therapy for diarrhea	82.16%	0.27	0.11, 0.42	0.002	89.45%	0.27	0.06, 0.47	0.014	93.43%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence, OOP and GDP
Careseeking for Pneumonia	18.87%	0.09	-0.04, 0.21	0.184	23.70%	0.09	-0.04, 0.22	0.205	60.71%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence, OOP and GDP

[1] - the model only includes the baseline coverage rate as the predictor
[2] - the model includes baseline coverage rate and ODA as predictors
[3] - most optimal model associated with largest adjusted R-squared for the given set of predictors
* - presented are beta coefficients, 95%CI and p-values for ODA
† - beta coefficient represents the estimated percentage point difference in annualized change in coverage for countries that differ by $1 in ODA
‡ - 95%Confidence Interval for the beta coefficient

Table 6: Characteristics of identified articles presenting quantified measures of coverage change for indicator themes of family planning, childhood vaccinations and infant feeding.

Publication Date	**Articles (%, n=134)**
1990- 1999	25%
2000-2011	75%
Country of Origin	
Industrialized Countries, including US	60% (US 37%)
Non-industrialized Countries	40%
Number of Coverage measurements, range	2-20
Less than 3 measurements	55%
3 or more	45%
Method of Coverage Change Assessment*	
Absolute differences	84%
Relative Change	8%
Percentage change	7%
Average annual rate of change	5%
Regression analysis	4%
Compound growth rate	1%
P-value Noted with Change Assessment	
Yes	57%
No	43%

*Numbers add up to more than 100% because some articles employed more than one method.

Table 7: Methods of computing coverage change

Method	Formula	Unit	Interpretation
1. Average annual rate of change (AAR)	$AAR = \frac{svy2 - svy1}{\#\ of\ years}$	Percentage points	Average percentage point change in the coverage rate per year.
2. Regression analyses			
a. Linear regression	a.) E[Coverage] = $\beta_0 + \beta_1\ Time_1 + \ldots \beta_n\ X_n$	Percentage Points	a.) Average change in the coverage rate per year (β_1). b.) Percent change in odds of coverage (odds of coverage = coverage/(1-coverage) per year (exp (β_1)
b. Logistic regression	b.) Log odds[Coverage] = $\beta_0 + \beta_1\ Time_1 + \ldots \beta_n\ X_n$	Percentage	
3. Absolute change	$Abs.change = svy2 - svy1$	Percentage Points	The difference in coverage rates between two time points.
4. Compound annual growth rate	$CAGR = \left(\frac{svy2}{svy1}\right)^{\left(\frac{1}{\#\ of\ years}\right)} - 1$	Percentage	The change in coverage rate per year that takes into account the change in the previous year.
5. Percentage change	$\%\ Change = \frac{svy2 - svy1}{svy1} \times 100$	Percentage	Percent change in coverage rate as compared to the previous time point.
6. Relative change	$Rel.change = \frac{svy2}{svy1}$	No Unit	The ratio of coverage between two tine points.

*svy2- Coverage measurement from latest survey, svy1- Coverage measurement from earlier survey

Table 8: Differences in Coverage Change Results by Metric using the DTP data from 1990 to 2010

	All time points	Two time points only	Botswana	Cambodia	Congo	Zimbabwe	Unit
Average Annual Rate		x	0.20pps	2.70pps	0.55pps	-0.25pps	Percentage Points
Linear Regression	x		0.15pps	3.14pps	1.48pps	-0.79pps	Percentage Points
Absolute Change		x	4pps	54pps	11pps	-5pps	Percentage Points
Compound Annual Change Rate		x	0.21%	4.52%	0.65%	-0.29%	Percent
Percentage Change		x	4%	142%	14%	-6%	Percent
Relative Change		x	1.04	2.42	1.14	0.94	None

Table 9: Differences in Coverage Change Results by Metric using the DTP data from 2000 to 2010

	All time points	Two time points only	Botswana	Cambodia	Congo	Zimbabwe	Unit
Average Annual Rate		x	-0.10pps	3.30pps	5.70pps	0.40pps	Percentage Points
Linear Regression	x		-0.10pps	3.49pps	6.12pps	0.20pps	Percentage Points
Absolute Change		x	-1pps	33pps	57pps	4pps	Percentage Points
Compound Annual Change Rate		x	-0.10%	4.54%	10.55%	0.50%	Percent
Percentage Change		x	-1%	56%	173%	5%	Percent
Relative Change		x	0.99	1.56	2.73	1.05	None

Table 10: Comparison of predicted future rates versus actual future rates.

	1990 change rate used to predict 2005 coverage rates (15 years)				**2000 change rate used to predict 2007 coverage rates (7 years)**			
Year		1990				2000		
	Botswana	Cambodia	Congo	Zimbabwe	Botswana	Cambodia	Congo	Zimbabwe
Regression	94pps	85pps	100pps	76pps	96pps	83pps	76pps	80pps
AAR	95pps	79pps	87pps	84pps	96pps	82pps	73pps	82pps
CAGR	95%	74%	87%	84%	96%	81%	67%	82%
Year		2005				2007		
Actual Rates	**96%**	**82%**	**65%**	**65%**	**96%**	**82%**	**80%**	**72%**

* pps – percentage points

Table 11: Background Characteristics of Nigerian women utilizing maternal health services by SES

		Poor		Rich	
		n	%	N	%
	Total	**8992**	**100**	**5530**	**100**
Current Age	15-19	810	9	221	4
	20-24	1,860	21	939	17
	25-29	2,214	25	1,668	30
	30-34	1,617	18	1,297	23
	35-39	1,298	14	862	16
	40-44	752	8	420	8
	45-49	441	5	123	2
Age at first birth	<15	1,038	13	275	5
	15-19	4,204	53	1,708	32
	20-24	2,102	26	2,112	40
	25-29	489	6	906	17
	30-34	84	1	221	4
	35+	19	<1	40	1
Marital Status	Unmarried	427	5	319	6
	Married	8,564	95	5,211	94
Parity	1st	1,359	15	1,159	21
	2nd	1,323	15	1,066	19
	3rd	1,206	13	971	18
	>=4th	5,104	57	2,334	42
Maternal education	None	6,469	72	837	15
	Primary	1,773	20	1,265	23
	Secondary or higher	750	8	3,428	62
Religion	Christian	2,571	29	3,322	60
	Muslim	6,088	68	2,137	39
	Other	268	3	46	1
Locality	Urban	542	6	3,397	61
	Rural	8,450	94	2,133	39
Ethnicity	Ibo	378	4	995	18
	Yoruba	320	4	1,509	27
	Hausa	4,536	51	945	17
	Others	3,709	41	2,050	37
Maternal employment	No	3,559	40	1,598	29
	Yes	5,373	60	3,897	71
Region	North	7,732	86	2,199	40
	South	1,260	14	3,331	60
Problems accessing care	No	590	7	1,753	34
	Yes	7,835	93	3,417	66

Table 12: Percentage of women with 4+ ANC or skilled birth attendant use by background characteristics, Nigeria, 2008 DHS

	4+ ANC Visits				Skilled Birth Attendant Use			
	Poor		Rich		Poor		Rich	
Current Age								
15-19	95	6%	100	3%	118	10%	122	3%
20-24	304	20%	542	15%	238	20%	627	16%
25-29	417	27%	1,103	31%	306	25%	1,241	31%
30-34	297	19%	904	25%	208	17%	1,012	25%
35-39	239	15%	586	16%	189	16%	659	16%
40-44	126	8%	282	8%	90	7%	299	7%
45-49	80	5%	67	2%	65	5%	79	2%
Age at first birth								
<15	139	10%	141	4%	88	8%	137	4%
15-19	672	48%	1,032	30%	554	49%	1,065	27%
20-24	456	33%	1,391	40%	366	33%	1,651	42%
25-29	111	8%	683	20%	94	8%	807	21%
30-34	19	1%	171	5%	15	1%	207	5%
35+	4	0%	30	1%	4	0%	34	1%
Marital Status								
Unmarried	110	7%	173	5%	109	9%	212	5%
Married	1,448	93%	3,411	95%	1,105	91%	3,827	95%
Parity								
1st	247	16%	764	21%	258	21%	920	23%
2nd	230	15%	708	20%	187	15%	835	21%
3rd	218	14%	639	18%	145	12%	733	18%
>=4th	863	55%	1,473	41%	624	51%	1,551	38%
Maternal Education								
None	717	46%	382	11%	450	37%	347	9%
Primary	549	35%	788	22%	450	37%	817	20%
Secondary or higher	292	19%	2,414	67%	314	26%	2,875	71%
Religion								
Christian	812	53%	2,208	62%	760	63%	2,690	67%
Muslim	696	45%	1,332	37%	429	35%	1,305	32%
Other	38	2%	26	1%	20	2%	27	1%

	4+ ANC Visits				Skilled Birth Attendant Use			
	Poor		Rich		Poor		Rich	
Locality								
Urban	188	12%	2,348	66%	130	11%	2,603	64%
Rural	1,370	88%	1,236	34%	1,084	89%	1,436	36%
Ethnicity								
Ibo	129	8%	685	19%	154	13%	931	23%
Yoruba	164	11%	1,141	32%	174	14%	1,296	32%
Hausa	397	25%	461	13%	177	15%	389	10%
Others	865	56%	1,278	36%	705	58%	1,403	35%
Maternal employment		p = 0.269				p = 0.645		
No	*426*	*27%*	*926*	*26%*	*308*	*26%*	*1,052*	*26%*
Yes	*1,125*	*73%*	*2,638*	*74%*	*899*	*74%*	*2,966*	*74%*
Region								
North	1,113	71%	1,295	36%	723	60%	1,310	32%
South	445	29%	2,289	64%	491	40%	2,729	68%
Problems access health care								
No	194	13%	1,320	40%	186	16%	1,502	39%
Yes	1,251	87%	2,022	60%	979	84%	2,347	61%

Table 13a: Univariate logistic regression models predicting 4 or more antenatal care visits, Nigeria 2008 DHS

	4+ ANC visits							
Current Age	Poor				Rich			
15-19	ref	p-value	LCI	UCI	ref	p-value	LCI	UCI
20-24	1.58	0.001	1.21	2.05	1.56	0.007	1.13	2.15
25-29	1.86	0.000	1.41	2.44	2.30	0.000	1.68	3.15
30-34	1.77	0.000	1.33	2.35	2.65	0.000	1.89	3.72
35-39	1.79	0.000	1.32	2.41	2.52	0.000	1.79	3.56
40-44	1.55	0.004	1.15	2.09	2.32	0.000	1.60	3.37
45-49	1.68	0.003	1.20	2.34	1.38	0.206	0.84	2.26
Age at first birth								
<15	ref				ref			
15-19	1.25	0.031	1.02	1.54	1.50	0.002	1.16	1.93
20-24	1.93	0.000	1.53	2.45	1.89	0.000	1.46	2.43
25-29	1.95	0.000	1.44	2.63	3.03	0.000	2.29	4.01
30-34	2.00	0.016	1.14	3.49	3.36	0.000	2.20	5.13
35+	1.67	0.403	0.50	5.60	2.47	0.033	1.07	5.68
Marital Status								
Unmarried	ref				ref			
Married	0.56	0.000	0.42	0.73	1.70	0.000	1.32	2.19
Parity								
1st	ref				ref			
2nd	0.92	0.432	0.73	1.14	1.00	0.986	0.82	1.22
3rd	0.99	0.920	0.79	1.24	0.99	0.914	0.81	1.21
>=4th	0.89	0.224	0.74	1.07	0.85	0.056	0.72	1.00
Maternal Education								
None	ref				ref			
Primary	3.62	0.000	2.99	4.39	1.89	0.000	1.53	2.34
Secondary or higher	5.64	0.000	4.47	7.12	2.76	0.000	2.27	3.36

Religion								
Christian	ref				ref			
Muslim	0.28	0.000	0.23	0.35	0.89	0.149	0.75	1.04
Other	0.38	0.000	0.23	0.62	0.56	0.107	0.28	1.13
Locality								
Urban	ref				ref			
Rural	0.36	0.000	0.30	0.44	0.59	0.000	0.49	0.70
Ethnicity								
Ibo	ref				ref			
Yoruba	2.28	0.002	1.35	3.86	1.53	0.001	1.19	1.96
Hausa	0.21	0.000	0.14	0.31	0.46	0.000	0.36	0.59
Others	0.62	0.017	0.42	0.92	0.73	0.007	0.58	0.92
Current maternal employment								
No	ref				ref			
Yes	1.96	0.000	1.64	2.34	1.59	0.000	1.38	1.83
Region								
North	ref				ref			
South	3.45	0.000	2.65	4.50	1.80	0.000	1.52	2.12
Problems accessing health care								
No	ref				ref			
Yes	0.36	0.000	0.27	0.48	0.48	0.000	0.40	0.57

Table 13b: Univariate logistic regression models: Use of skilled birth attendants, Nigeria 2008 DHS

	Use of Skilled Birth Attendants							
	Poor				Rich			
Current Age								
15-19	ref	p-value	LCI	UCI	ref	p-value	LCI	UCI
20-24	0.87	0.288	0.67	1.13	1.50	0.014	1.08	2.08
25-29	0.97	0.830	0.74	1.27	2.32	0.000	1.67	3.21
30-34	0.85	0.283	0.64	1.14	2.84	0.000	2.03	3.97
35-39	1.06	0.691	0.80	1.41	2.50	0.000	1.75	3.57
40-44	0.82	0.238	0.59	1.14	1.86	0.002	1.27	2.73
45-49	0.95	0.804	0.66	1.38	1.55	0.070	0.97	2.48
Age at first birth								
<15	ref				ref			
15-19	1.64	0.000	1.27	2.12	1.68	0.000	1.28	2.20
20-24	2.32	0.000	1.77	3.05	3.85	0.000	2.92	5.07
25-29	2.69	0.000	1.91	3.79	8.17	0.000	5.81	11.49
30-34	2.77	0.002	1.47	5.20	14.90	0.000	7.54	29.47
35+	3.49	0.047	1.02	11.98	5.01	0.002	1.85	13.56
Marital Status								
Unmarried	ref				ref			
Married	0.38	0.000	0.30	0.49	1.51	0.007	1.12	2.03
Parity								
1st	ref				ref			
2nd	0.69	0.001	0.55	0.86	1.00	0.993	0.79	1.26
3rd	0.57	0.000	0.45	0.73	0.81	0.075	0.64	1.02
>=4th	0.59	0.000	0.49	0.70	0.52	0.000	0.43	0.64
Maternal Education								
None	ref				ref			
Primary	4.88	0.000	3.98	5.99	2.70	0.000	2.15	3.40
Secondary or higher	11.30	0.000	8.75	14.60	7.91	0.000	6.22	10.07
Religion								
Christian	ref				ref			
Muslim	0.16	0.000	0.12	0.20	0.34	0.000	0.28	0.42
Other	0.18	0.000	0.10	0.32	0.29	0.000	0.15	0.57

	Use of Skilled Birth Attendants							
	Poor				Rich			
Locality								
Urban	ref				ref			
Rural	0.44	0.000	0.31	0.64	0.64	0.000	0.51	0.80
Ethnicity								
Ibo	ref				ref			
Yoruba	1.48	0.232	0.78	2.82	0.31	0.000	0.21	0.46
Hausa	0.05	0.000	0.03	0.08	0.04	0.000	0.02	0.05
Others	0.33	0.000	0.20	0.54	0.13	0.000	0.09	0.19
Current maternal employment								
No	ref				ref			
Yes	2.21	0.000	1.79	2.72	1.66	0.000	1.40	1.98
Region								
North	ref				ref			
South	6.72	0.000	4.99	9.05	4.15	0.000	3.37	5.11
Problems accessing health care								
No	ref				ref			
Yes	0.28	0.000	0.20	0.37	0.36	0.000	0.30	0.45

Table 14a: Determinants of 4 or more antenatal care use among poor and rich women. Nigeria 2008 DHS

		Poor Women		Rich Women	
		Adjusted OR	**p value**	**Adjusted OR**	**p value**
Current Age	15-19 (ref)				
	20-24	1.157	0.362	1.214	0.341
	25-29	1.372	0.063	*1.573*	*0.028*
	30-34	1.370	0.074	*1.646*	*0.024*
	35-39	1.304	0.154	*1.612*	*0.030*
	40-44	1.101	0.600	*1.932*	*0.004*
	45-49	1.415	0.101	1.269	0.444
Age at first birth	<15 (ref)				
	15-19	1.179	0.170	1.169	0.297
	20-24	*1.419*	*0.009*	1.078	0.616
	25-29	1.384	0.057	*1.433*	*0.027*
	30-34	1.558	0.120	1.486	0.109
	35+	0.870	0.871	1.165	0.727
Marital Status	Unmarried (ref)				
	Married	0.996	0.982	*1.359*	*0.034*
Maternal Education	None (ref)				
	Primary	*2.185*	*0.000*	*1.509*	*0.001*
	Secondary or higher	*2.876*	*0.000*	*2.012*	*0.000*
Religion	Christian (ref)				
	Muslim	0.857	0.363	*1.696*	*0.000*
	Other	0.611	0.065	0.876	0.768
Locality	Urban (ref)				
	Rural	*0.400*	*0.000*	*0.685*	*0.000*
Ethnicity	Ibo (ref)				
	Yoruba	*2.744*	*0.001*	1.244	0.101
	Hausa	*0.541*	*0.043*	*0.490*	*0.000*
	Others	0.925	0.775	0.879	0.319
Maternal employment	No (ref)				
	Yes	*1.298*	*0.003*	1.192	0.030
Region	North (ref)				
	South	1.100	0.653	1.223	0.179

Table 14b: Determinants of skilled birth attendant use among poor and rich women. Nigeria 2008 DHS

		Poor Women		Rich Women	
		Adjusted OR	**p value**	**Adjusted OR**	**p value**
Current Age	15-19 (ref)				
	20-24	*0.590*	*0.007*	1.132	0.598
	25-29	0.690	0.093	*1.648*	*0.069*
	30-34	0.671	0.136	*2.222*	*0.007*
	35-39	0.809	0.438	*2.240*	*0.011*
	40-44	0.683	0.208	*2.378*	*0.006*
	45-49	0.924	0.814	*2.302*	*0.039*
Age at First Birth	<15 (ref)				
	15-19	1.244	0.144	1.052	0.751
	20-24	1.245	0.200	1.239	0.206
	25-29	1.298	0.235	1.429	0.098
	30-34	1.262	0.533	1.730	0.165
	35+	1.359	0.642	0.682	0.505
Parity	1st (ref)				
	2nd	0.828	0.187	0.859	0.341
	3rd	*0.634*	*0.007*	*0.676*	*0.037*
	>=4th	0.753	0.134	*0.523*	*0.001*
Marital Status	Unmarried (ref)				
	Married	1.076	0.659	*1.675*	*0.007*
Maternal Education	None (ref)				
	Primary	*2.116*	*0.000*	*1.559*	*0.002*
	Secondary or higher	*3.399*	*0.000*	*3.199*	*0.000*
Religion	Christian (ref)				
	Muslim	0.741	0.220	*1.468*	*0.006*
	Other	*0.244*	*0.000*	0.440	0.106
Locality	Urban (ref)				
	Rural	*0.512*	*0.010*	*0.725*	*0.005*
Ethnicity	Ibo (ref)				
	Yoruba	1.793	0.102	*0.259*	*0.000*
	Hausa	*0.168*	*0.000*	*0.057*	*0.000*
	Other	*0.528*	*0.030*	*0.174*	*0.000*
Maternal employment	No (ref)				
	Yes	*1.253*	*0.046*	1.047	0.657

		Poor Women		Rich Women	
		Adjusted OR	**p value**	**Adjusted OR**	**p value**
Region	North (ref)				
	South	1.406	0.164	1.104	0.483

Figures

Figure 1: Flow Chart for Country Selection

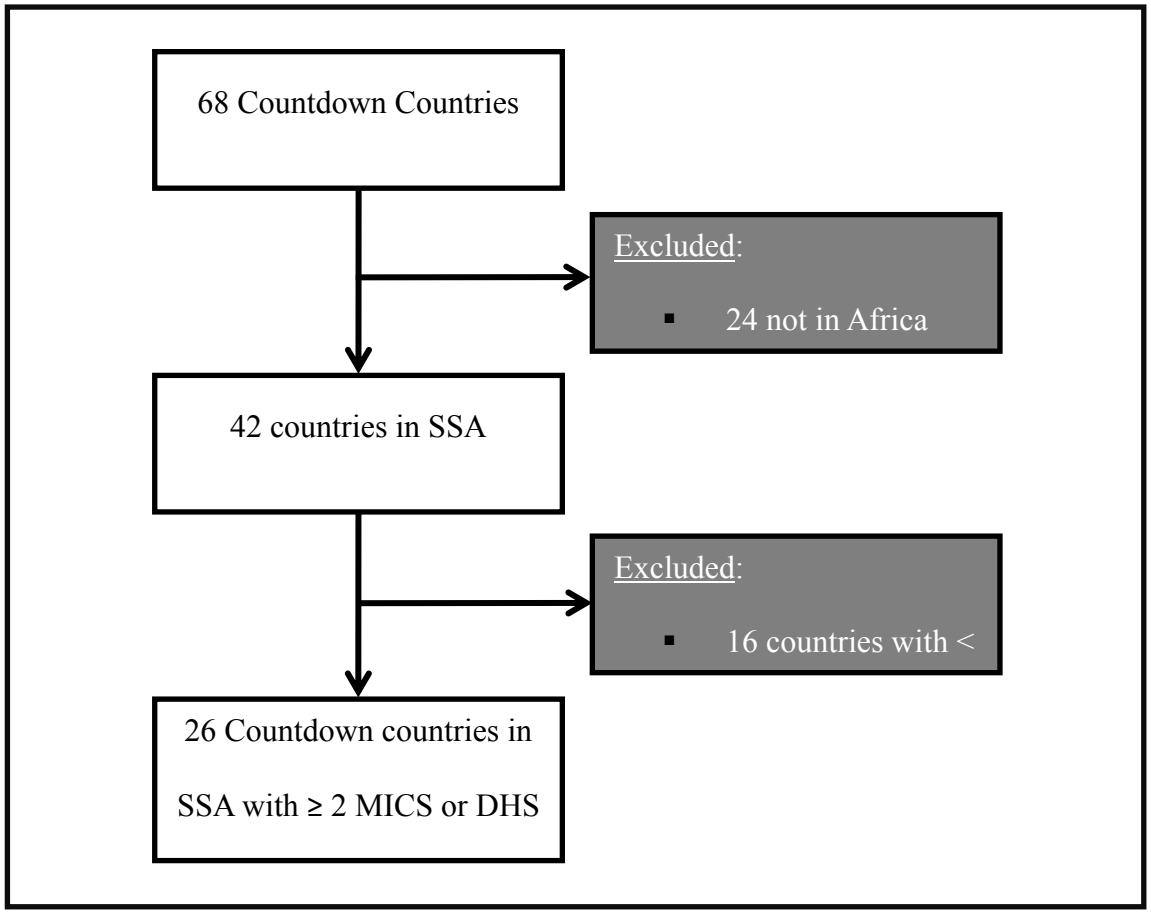


Figure 2: Flow chart for Article Selection

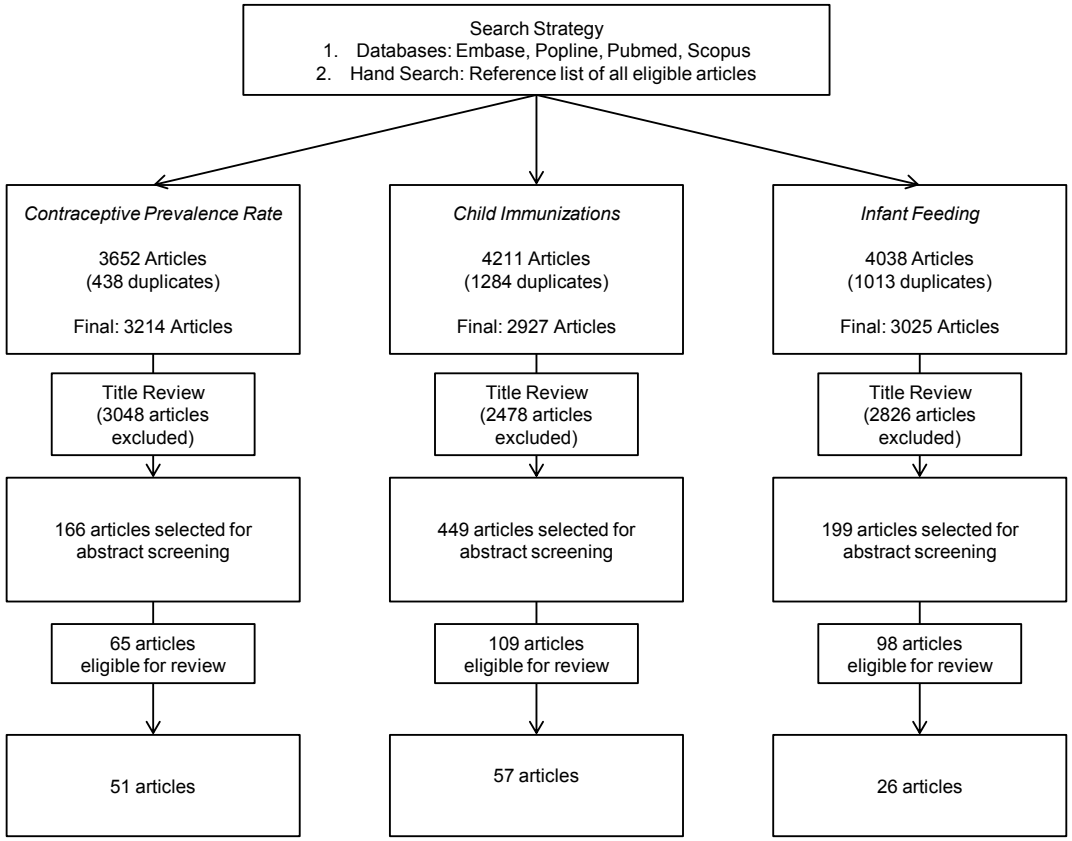
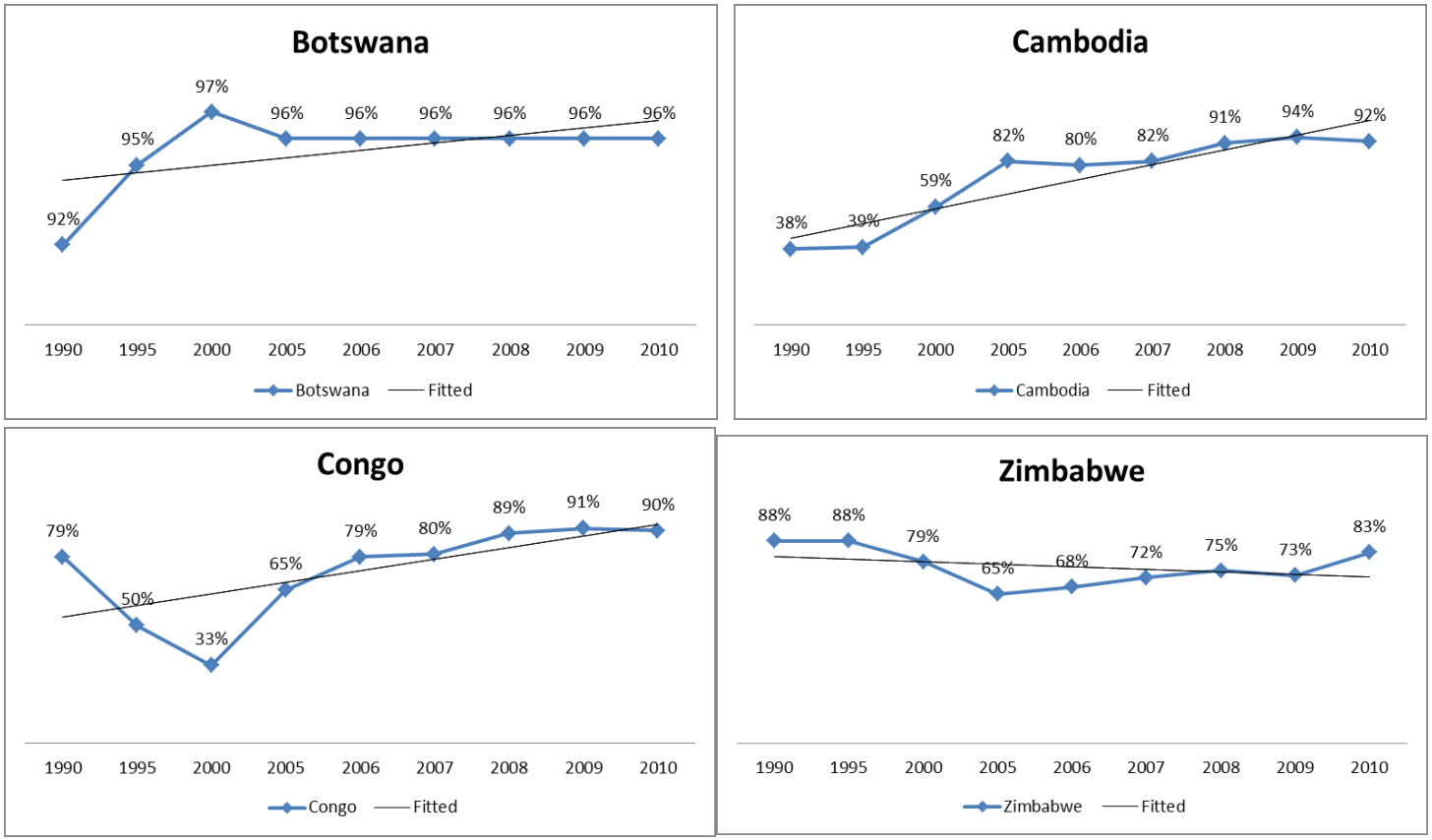


Figure 3: Plots of DTP3 coverage (%) trends between 1990 and 2010 in Botswana, Cambodia, Congo, and Zimbabwe



Source: Immunization Summary Data 1990 – 2010, WHO/UNICEF, http://www.childinfo.org/files/immunization_summary_en.pdf

Appendices

Appendix 1: Countdown coverage indicators and the basis for their inclusion in the analysis.

Coverage Indicators	Coverage estimate based solely on survey data?	Comparable measurement in DHS & MICS?	MICS Measurement	DHS Measurement	Consistent measurement since 2000?	Selected for analysis
Reproductive Health						
Contraceptive prevalence rate*	✓	✓	✓	✓	✓	
Unmet need for family planning	✓	✓	✓	✓	✓	
Maternal/Neonatal Health and Survival						
Antenatal care (at least one visit with a skilled attendant)	✓	✓	✓	✓	✓	✓
Intermittent preventive treatment for pregnant women	✓	✓	✓	✓	No	
Skilled attendant at birth	✓	✓	✓	✓	✓	✓
Postnatal visit for mother	✓	No	No	✓	✓	
Postnatal visit for baby	✓	No	No	✓	No	
HIV+ pregnant women receiving ARVs for PMTCT	No	No	No	✓	No	
Neonatal tetanus protection	No	✓	✓	✓	✓	
Neonatal and Child Survival						
Early initiation of breastfeeding (within one hour of birth)	✓	✓	✓	✓	No	
Exclusive breast-feeding rate (<6months)	✓	✓	✓	✓	No	
Complementary feeding rate (6-9 months)	✓	✓	✓	✓	✓	
Vitamin A supplementation 2 dose	No	✓	✓	✓	✓	
Measles immunisation coverage	No	✓	✓	✓	✓	
DPT3 immunisation coverage	No	✓	✓	✓	✓	
Hib3 immunisation coverage	No	✓	✓	✓	✓	
Under-fives sleeping under ITNs	✓	✓	✓	✓	✓	✓
Antimalarial treatment (under-fives)	✓	✓	✓	✓	✓	

Care seeking for pneumonia	✓	✓	✓	✓	✓	✓
Antibiotic treatment for pneumonia	✓	✓	✓	✓	No	

* CPR not included in this analysis due to lack of specific ODA for family planning

Appendix 2: Details on the statistical methods

Coverage rate estimates. Coverage rates, our main outcome variables, were recalculated using MICS or DHS survey data for each country. The coverage rates and the standard errors were estimated using survey data analysis module available in STATA 11.[1] The module accounts for the complex sampling design of MICS and DHS surveys. The calculated estimates were compared with the official figures in the DHS/MICS reports, and any differences were reconciled by consulting survey staff members or by adhering to the standard definitions of the coverage indicators used in the Countdown to 2015.[2]

Estimating annualized change in coverage. We estimated annualized change in coverage rates using generalized linear models with an identity link and binomial distribution, with year of survey as the main predictor. We used variance estimates that are robust to model misspecification known as Huber/White/sandwich variance estimator as described by Huber (1967)[3] and White (1980)[4]. The estimator is generalized to clustered data where the observations within cluster are not independent, but the clusters themselves are independent (e.g., regions within a country). The "meat" of the sandwich is substituted by a matrix that represents the outer product of *cluster-*

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[1] StataCorp. 2009. Stata Statistical Software: Release 11. College Station, TX: StataCorp LP

[2] Requejo J, Bryce J and the Countdown to 2015 Writing Team (2010) Countdown to 2015 Decade Report (2000-2010). Washington DC: WHO and UNICEF. ISBN 978 92 4 159957 3.

[3] Huber, P. J. The behavior of maximum likelihood estimates under nonstandard conditions. In *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability*. 1967. Berkeley, CA: University of California Press, vol. 1, 221–233.

[4] White, H. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica* 1980. 48: 817–830.

level scores, where within each cluster the cluster-level score is obtained by summing the observation-level scores[5].

Regression models. To explore the effect of the covariates (including ODA) on the coverage outcomes, we used random-effects meta-regression models on country-level coverage data to account for both between- and within-country variability of coverage estimates. The meta-regression method [6] is implemented using the *metareg* command available in Stata 10/11.[7] As implemented in STATA, the beta coefficients are estimated using the restricted maximum likelihood (REML) algorithm that maximizes residual (restricted) log-likelihood.[5] The method first estimates the between-country variance, and then uses weighted least-squares to estimate the beta coefficients.

Random or mixed-effects meta-regression assumes that the underlying country-specific coverage rates, θ_i vary among the countries and follow a normal distribution with a common mean, θ. For a coverage rate in the i'th country, θ_i the model can be represented as:

$$\hat{\theta}_i = \theta + u_i + \varepsilon_i = \beta X_i + u_i + \varepsilon_i$$

where u_i are the country-level random-effects that are normally distributed with zero mean and τ^2 – between-country variance, and ε_i are the residuals, which are also normally distributed with zero mean and σ^2 – country-specific variance.

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[5] Williams, R. L. A note on robust variance estimation for cluster-correlated data. *Biometrics* 2000. 56: 645–646

[6] Thompson SG, Higgins JPT. How should meta-regression analyses be undertaken and interpreted? Statistics In Medicine. 2002; 21:1559-1573.

[7] Harbord RM, Higgins JPT. Meta-regression in Stata. The stata journal. 2008; 8:493-519. In Meta-Analysis in Stata: an Updated Collection form the Stata Journal. Sterne JAC [editor]. Stata Press.

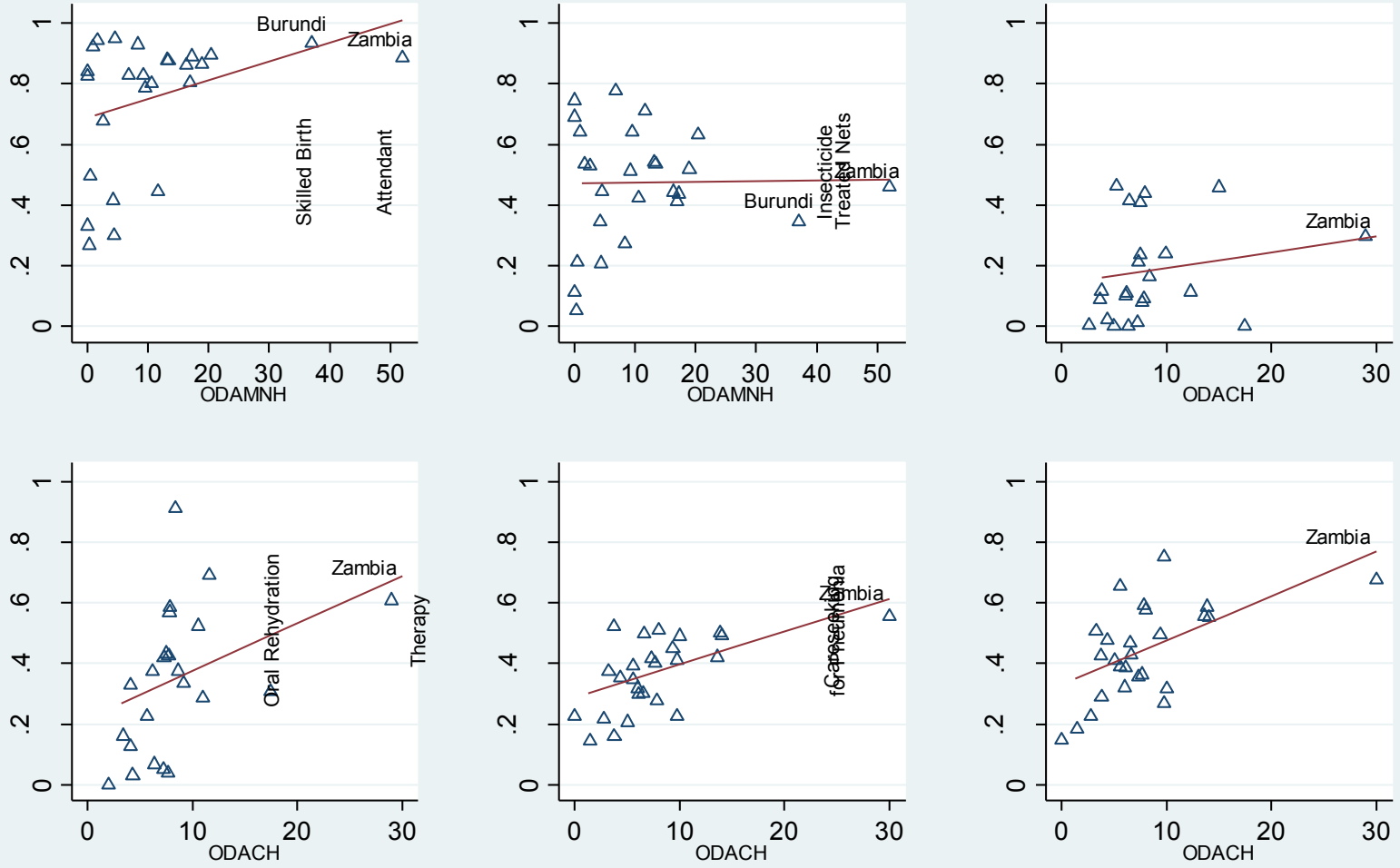
Selection of covariates was achieved by looking at the proportion of between-country variance explained by the set of the covariates in the model, adjusted R-squared. The adjusted R-squared is calculated by the *metareg* program in STATA and represents the proportion of the relative reduction in the overall between-study variability:

$$\hat{R}^2{}_{adj} = \frac{\widehat{\tau^2}_0 - \widehat{\tau^2}}{\widehat{\tau^2}_0}$$

where $\widehat{\tau^2}_0$ is the estimated overall between-country variance in the model with no covariates, and the τ^2 is the estimated between-country variance in the model with the given set of covariates. As noted by Harbord and Higgins,[5] the adjusted R-squared can be negative if the set of covariates explains less of the between-country variability than expected by chance.

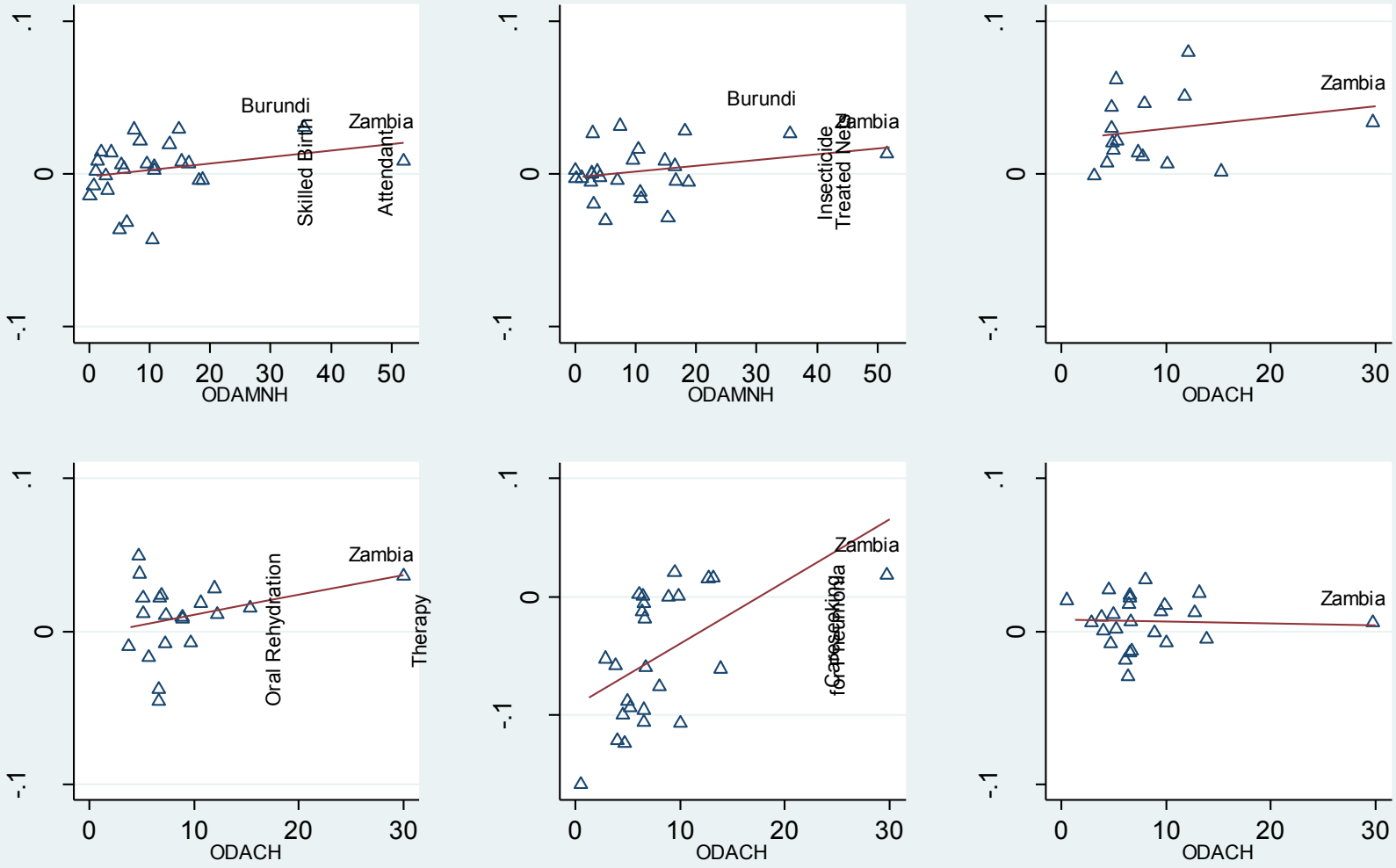
Appendix 3a & 3b: Graphical plots of the predictor and outcome variables, with potential influential data points highlighted.

3a: Plots of the unadjusted relationship between levels of intervention coverage and ODA with potential influential data points highlighted, 26 countries in sub-Saharan Africa



Absolute Coverage Rates- Most recent coverage estimate (%)
ODA- Official Development Assistance to maternal and newborn health (MNH) or child health (CH)
ODA- US$ per live birth or US$ per child

3b: Plots of the unadjusted relationship between annualized change in intervention coverage and ODA with potential influential data points highlighted, 26 countries in sub-Saharan Africa



Annualized Change in Coverage- Annualized change between most recent coverage estimate and previous estimate since 2000 (% points)
ODA- Official Development Assistance to maternal and newborn health (MNH) or child health (CH)
ODA- US$ per live birth or US$ per child

Appendix 4: Comparison of results for Model 3 with and without influential points for levels and annualized changes in coverage, 26 countries in sub-Saharan Africa

4a: Results of meta-regression models estimating the effect of ODA on coverage levels for selected interventions, 26 countries in sub-Saharan Africa using the most optimal model (Model 3 in Table 4) with and without the potentially influential points

Coverage Indicators	Model 3: All Data[1]*				Model 3: Excluding Potentially Influential Points[12]*				
	Beta†	95%CI‡	p-value	adj. R^2	Beta†	95%CI‡	p-value	adj. R^2	Included Covariates
Antenatal Care	0.12	-0.22, 0.47	0.459	85.98%	0.11	-0.87, 1.09	0.817	85.08%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence
Skilled Attendant at Birth	0.09	-0.19, 0.37	0.525	84.39%	0.16	-0.49, 0.81	0.606	84.15%	Baseline Coverage and ODA
Use of Insecticide Treated Bednets	-0.13	-1.31, 1.06	0.813	56.97%	-0.44	-3.88, 3.01	0.780	54.07	Baseline Coverage, ODA, Maternal Education, Governance, HW density
Exclusive Breastfeeding	0.79	-0.12, 1.72	0.086	77.46%	1.69	-0.27, 3.66	0.085	51.82%	Baseline Coverage and ODA
Oral Rehydration Therapy for diarrhea	1.10	0.00, 2.20	0.050	58.69%	1.76	-0.04, 3.57	0.055	56.46%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence, OOP and GDP
Careseeking for Pneumonia	0.51	-0.32, 1.34	0.205	81.31%	0.58	-1.10, 2.26	0.466	77.61%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence, OOP and GDP

[1] - most optimal model associated with largest adjusted R-squared for the given set of predictors

[2] – potentially influential points are excluded

* - presented are beta coefficients, 95%CI and p-values for ODA

† - beta coefficient represents the estimated percentage point difference in coverage for countries that differ by $1 in ODA

‡ - 95%Confidence Interval for the beta coefficient

4b: Results of meta-regression models estimating the effect of ODA on annualized coverage levels for selected interventions, 26 countries in sub-Saharan Africa using the most optimal model (Model 3 in Table 5) with and without the potentially influential points

Annualized change in Coverage Indicators	Model 3: All Data[1]*				Model 3: Excluding Potentially Influential Points[12]*				
	Beta†	95%CI‡	p-value	adj. R^2	Beta†	95%CI‡	p-value	adj. R^2	Included Covariates
Antenatal Care	0.04	-0.02, 0.1	0.175	10.23%	0.00	-0.13, 0.13	0.969	20.58%	Baseline Coverage, ODA, Maternal Education, Governance
Skilled Attendant at Birth	0.04	-0.01, 0.09	0.095	7.30%	0.04	-0.07, 0.15	0.427	-7.08%	Baseline Coverage and ODA
Use of Insecticide Treated Bednets	-0.09	-0.42, 0.24	0.522	42.29%	0.07	-0.78, 0.91	0.850	37.63%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence, OOP and GDP
Exclusive Breastfeeding	0.12	-0.11, 0.35	0.275	16.64%	0.25	-0.31, 0.82	0.346	2.45%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence
Oral Rehydration Therapy for diarrhea	0.27	0.06, 0.47	0.014	93.43%	0.46	0.05, 0.86	0.030	93.31%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence, OOP and GDP
Careseeking for Pneumonia	0.09	-0.04, 0.22	0.205	53.81%	0.11	-0.17, 0.39	0.405	57.96%	Baseline Coverage, ODA, Maternal Education, Governance, HW density, HIV prevalence, OOP and GDP

[1] - most optimal model associated with largest adjusted R-squared for the given set of predictors the model only includes the baseline coverage rate as the predictor

[2] - potentially influential points are excluded

* - presented are beta coefficients, 95%CI and p-values for ODA

† - beta coefficient represents the estimated percentage point difference in annualized change in coverage for countries that differ by $1 in ODA

‡ - 95%Confidence Interval for the beta coefficient

Appendix 5: Countdown Indicators

	Nutrition
1	Exclusive breastfeeding (<6 months)
2	Complementary feeding (6 - 9 months)
3	Vitamin A supplementation
	Child Health
4	Measles immunization coverage
5	Three doses of combined diphtheria, tetanus and pertussis vaccine immunization coverage
6	Three doses of *Haemophilus influenzae* type B vaccine immunization coverage
7	Oral rehydration therapy and continued feeding
8	Insecticide-treated net use
9	Antimalarial treatment
10	Prevention of mother-to-child transmission of HIV
11	Careseeking for pneumonia
12	Antibiotic treatment for pneumonia
	Maternal and Newborn Health
13	Contraceptive prevalence rate
14	Adolescent birth rate
15	Unmet need for family planning
16	Antenatal care (at least one visit)
17	Antenatal care (four or more visits)
18	Neonatal tetanus protection
19	Intermittent preventive treatment for malaria during pregnancy
20	Skilled birth attendant at birth
21	Caesarean section rate
22	Early initiation of breastfeeding
23	Postnatal care for mothers
24	Postnatal care for babies who were born at home
	Water and Sanitation
25	Use of improved drinking water sources
26	Use of improved sanitation facilities

Appendix 6: Search Terms

Indicator	Contraceptive Prevalence Rate	Child Immunizations	Exclusive Breastfeeding
Embase	'contraceptive' OR 'contraceptive agent' OR 'contraceptive agent':de,ab,ti OR 'birth control' OR 'birth control':de,ab,ti OR 'contraceptive device' OR 'contraceptive device':de,ab,ti OR 'contraceptive prevalence'	'measles vaccine'/exp OR 'measles vaccine' OR 'measles vaccine':de,ab,ti OR 'measles vaccination'/exp OR 'measles vaccination' OR 'measles vaccination':de,ab,ti OR 'measles mump rubella vaccine'/exp OR 'measles mump rubella vaccine' OR 'measles mump rubella vaccine':de,ab,ti OR 'diphtheria pertussis tetanus Haemophilus influenzae type b hepatitis B vaccine'/exp OR 'diphtheria pertussis tetanus Haemophilus influenzae type b hepatitis B vaccine' OR 'diphtheria pertussis tetanus Haemophilus influenzae type b hepatitis B vaccine':de,ab,ti OR 'Haemophilus influenzae type b vaccine'/exp OR 'Haemophilus influenzae type b vaccine' OR 'Haemophilus influenzae type b vaccine':de,ab,ti OR 'diphtheria pertussis tetanus vaccine'/exp OR 'diphtheria pertussis tetanus vaccine' OR 'diphtheria pertussis tetanus vaccine':de,ab,ti	breast feeding'/exp OR 'breast feeding' OR 'breast feeding':de,ab,ti OR 'infant feeding'/exp OR 'infant feeding' OR 'infant feeding':de,ab,ti
Popline	contraceptive prevalence survey	Keyword: measles / hib / pertussis / tetanus / diphtheria	Keyword: "Breastfeeding" & ="Infant"

Indicator	Contraceptive Prevalence Rate	Child Immunizations	Exclusive Breastfeeding
Pubmed	("Contraception/statistics and numerical data"[Mesh]) OR ("Contraception/trends"[Mesh]) OR ("Contraception"[All Fields] AND "statistics"[All Fields]) OR ("Contraception"[All Fields] AND "numerical data"[All Fields]) OR ("Contraception"[All Fields] AND "trends"[All Fields]) OR ("Contraception"[All Fields] AND "trend"[All Fields]) OR ("Contraceptive"[All Fields] AND "statistics"[All Fields]) OR ("Contraceptive"[All Fields] AND "numerical data"[All Fields]) OR ("Contraceptive"[All Fields] AND "trends"[All Fields]) OR ("Contraceptive"[All Fields] AND "trend"[All Fields]))	(("Measles"[Mesh] OR "Measles-Mumps-Rubella Vaccine"[Mesh] OR "Measles Vaccine"[Mesh]) OR ("Measles"[Text Word] OR "Measles-Mumps-Rubella Vaccine"[Text Word] OR "Measles Vaccine"[Text Word]) OR ((measles[Text Word]) AND (immunization[All Fields] OR "vaccination"[MeSH Terms]))) OR (("Diphtheria-Tetanus-Pertussis Vaccine"[Mesh] AND "Diphtheria Toxoid"[Mesh] AND "Diphtheria-Tetanus-acellular Pertussis Vaccines"[Mesh] AND "Diphtheria-Tetanus Vaccine"[Mesh]) OR (Diphtheria-Tetanus-Pertussis Vaccine[Text Word]) OR (Diphtheria vaccine[Text Word]) OR ("tetanus toxoid"[MeSH Terms] OR tetanus vaccine[Text Word]) OR ("pertussis vaccine"[MeSH Terms] OR pertussis vaccine[Text Word])) OR ((("Haemophilus Vaccines"[Mesh]) AND "Haemophilus influenzae type b polysaccharide vaccine" [Supplementary Concept]) OR (haemophilus influenzae vaccines[Text Word]) OR (HIB[Text Word] AND ("vaccination"[MeSH Terms] OR vaccination[Text Word] OR immunization[All Fields]))	"breast feeding"[MeSH] OR ("breast"[All Fields] AND "feeding"[All Fields]) OR "breast feeding"[All Fields]) OR ("exclusive"[All Fields] AND "breastfeeding"[All Fields]) OR "exclusive breastfeeding"[All Fields]OR "infant nutritional physiological phenomena"[MeSH Terms] OR ("infant"[All Fields] AND "nutritional"[All Fields] AND "physiological"[All Fields] AND "phenomena"[All Fields]) OR "infant nutritional physiological phenomena"[All Fields] OR ("complementary"[All Fields] AND "feeding"[All Fields]) OR "complementary feeding"[All Fields]

Indicator	Contraceptive Prevalence Rate	Child Immunizations	Exclusive Breastfeeding
Scopus	(Contraception) OR (Contraceptive) OR (Contraceptive Prevalence Rate) OR (Contraceptive agent) OR (Contraceptive device) OR (Reproductive Control Agents)	(measles vaccine) OR (measles vaccination) OR (measles immunization) OR (measles mump rubella immunization) OR (measles mump rubella vaccine) OR (diphtheria pertussis tetanus Haemophilus influenzae type b hepatitis B vaccine) OR (Haemophilus influenzae type b vaccine) OR (Haemophilus influenzae type b immunization) OR (diphtheria pertussis tetanus vaccine) OR (diphtheria vaccine) OR (HIB vaccine) OR (diphtheria immunization) OR (HIB immunization) OR (DTP vaccine) OR (DPT vaccine)(Keyword search)	(breast feeding) OR (breastfeeding) OR (exclusive breastfeeding) OR (exclusive breast feeding) OR (infant nutrition) OR (complementary feeding) (Keyword search)

	Mother & Child Terms	Data Collection Terms	Change Terms
Embase	infant'/exp OR 'infant' OR 'infant':de,ab,ti OR 'preschool child'/exp OR 'preschool child' OR ' preschool child':de,ab,ti OR 'child'/exp OR 'child' OR 'child':de,ab,ti OR 'newborn'/exp OR 'newborn' OR 'newborn':de,ab,ti OR 'baby'/exp OR 'baby' OR 'baby':de,ab,ti OR 'childhood'/exp OR 'childhood' OR 'childhood':de,ab,ti OR 'adolescent mother'/exp OR 'adolescent mother' OR 'adolescent mother':de,ab,ti OR 'maternal care'/exp OR 'maternal care'	health survey' OR 'health survey':de,ab,ti OR 'demographic and health survey' OR 'demographic and health survey':de,ab,ti OR 'multiple indicators survey':de,ab,ti OR 'multiple indicators survey' OR 'longitudinal study'/exp OR 'longitudinal study' OR 'longitudinal study':de,ab,ti OR 'population surveillance':de,ab,ti OR 'population surveillance' OR 'survey' OR 'DHS' OR 'MICS' OR 'national survey' OR 'DHS':de,ab,ti OR 'MICS':de,ab,ti OR 'survey':de,ab,ti	‘change’:ab,ti OR ‘changes’:ab,ti OR ‘rate’:ab,ti OR ‘rates’:ab,ti OR ‘difference’:ab,ti OR ‘differences’:ab,ti OR ‘trend’:ab,ti OR ‘trends’:ab,ti OR ‘differential’:ab,ti OR ‘differentials’:ab,ti OR ‘level’:ab,ti OR ‘levels’:ab,ti OR ‘coverage’:ab,ti

	Mother & Child Terms	Data Collection Terms	Change Terms
	OR 'maternal care':de,ab,ti OR 'child care'/exp OR 'child care' OR 'child care':de,ab,ti OR 'mother'/exp OR 'mother' OR 'mother':de,ab,ti OR 'pregnant woman'/exp OR 'pregnant woman' OR 'pregnant woman':de,ab,ti OR 'female'/exp OR 'female' OR 'female':de,ab,ti		
Popline			Title keyword: coverage* / trend* / level* / change* / rate* / difference* / differential* /Slope* /survey* /statistics / Longitudinal* /population surveillance

	Mother & Child Terms	Data Collection Terms	Change Terms
Pubmed	("Child"[Mesh] OR "Infant"[Mesh] OR "Infant, Newborn"[MH] OR "Child, Preschool"[MH] OR "child"[all] OR "infant"[all] OR "children"[all] OR "infants"[all] OR "childhood"[all] OR "preschool child"[all] OR "neonate"[all] OR "newborn"[all] OR "baby"[all])OR “mothers”[Mesh] OR "mother"[All Fields] OR "mothers"[All Fields]OR “adolescent mother”[All Fields] OR “Maternal care”[All Fields] OR “pregnant women”[Mesh] OR “pregnant woman”[All Fields] OR “pregnant women”[All Fields])	("Data Collection/statistics and numerical data"[Mesh] OR "Data Collection/trends"[Mesh] OR (“Data collection”[All Fields] and “statistics”[All Fields]) OR (“Data Collection”[All Fields] AND “trend”[All Fields]) OR (“Data Collection”[All Fields] AND “trends”[All Fields]) OR ("Health Surveys/statistics and numerical data"[Mesh]) OR ("Health Surveys/trends"[Mesh]) OR ("Health Surveys”[All Fields] AND “statistics"[All Fields]) OR ("Health Surveys”[All Fields] AND “numerical data"[All Fields]) OR ("Health Surveys”[All Fields] AND “trends"[All Fields]) OR ("Health Surveys”[All Fields] AND “trend"[All Fields]) OR ("Longitudinal studies/statistics and numerical data"[Mesh]) OR ("Longitudinal studies/trends"[Mesh]) OR ("Longitudinal studies”[All Fields] AND “statistics"[All Fields]) OR ("Longitudinal studies”[All Fields] AND “numerical data"[All Fields]) OR ("Longitudinal studies”[All Fields] AND “trends"[All Fields]) OR ("Longitudinal studies”[All Fields]	((("change"[Tiab]) OR ("changes"[Tiab]) OR ("rate"[Tiab]) OR ("rates"[Tiab]) OR ("difference"[Tiab]) OR ("differences"[Tiab]) OR ("trend"[Tiab]) OR ("trends"[Tiab]) OR ("differential"[Tiab]) OR ("differentials"[Tiab]) OR (“level”[Tiab]) OR(“levels”[Tiab]) OR (((“Panel” [Tiab])OR ("Panels"[Tiab])) AND ("data"[Tiab])) OR (“Growth Curve”[Tiab]) OR (“Slope”[Tiab]) OR (“Growth Curves”[Tiab]) OR (“Slopes”[Tiab]) OR ("Coverage"[Tiab]))

	Mother & Child Terms	Data Collection Terms	Change Terms
		AND “trend"[All Fields]) OR ("Longitudinal surveys”[All Fields]) OR ("Longitudinal survey”[All Fields]) OR “survey”[All Fields] OR “surveys”[All Fields] OR “population surveillance”[Mesh] OR “population surveillance”[All Fields])	
Scopus	(Child) OR (Infant) OR (Newborn) OR (childhood) OR (neonate) OR (baby) OR (mothers) OR (Maternal) OR (pregnant) OR (woman) OR (adolescent)(Keyword search)	(Data Collection) OR (trends) OR (statistics) OR (trend) OR (Health Surveys) OR (Health Survey) OR (numerical data) OR (Longitudinal studies) OR (Longitudinal study) OR (survey) OR (surveys) OR (population surveillance) (Keyword search)	(change) OR (rate) OR (difference) OR (trend) OR (differential) OR (level) OR (Slope) OR (Coverage) (Abstract search)

Appendix 7: Data Abstraction Form

1	Reviewer				
2	Date of Search				
3	Concept (Indicator)			Number of Articles Identified	
4	Endnote Record Number		Article ID: _____out of_____ articles e.g. 1 out of 300		
5	Published	□ Yes	□ No Source:_____ (working report, govt. docs, net document)		
6	First Author				
7	Title				
8	Journal/Source e.g. organization website				
9	Publication Year				
10	Language				
11	Country (List country name, check all that apply)	□ Developing Country :_____ □ Developed (industrialized) Country:_____ □ Multi-Country:_____ □ Other:_____			
12	Type of Study	□ Prevalence Studies □ Program Evaluation □ Reviews □ Cohort Study	□ Time Series Study □ Cross-sectional Study □ Other:_____		
13	What type of data was used? List survey name.				
14	Systematic review eligibility? What was assessed?	□ Trends in coverage □ Changes in coverage □ Differences	□ Other, please explain:		
15	Included in the review?	□ Yes □ No	□ If no, please explain:		
16	**IF ANSWER TO NUMBER 15 IS NO, PLEASE STOP.**				
17	Primary outcome measure?				

<table>
<tr><td>18</td><td>Other variables assessed?</td><td colspan="2"></td></tr>
<tr><td>19</td><td>Please describe the representativeness of the study?</td><td>□ National
□ Sub-national
□ Multi-national</td><td>□ If sub-national or other, please explain:</td></tr>
<tr><td>20</td><td>Over what time period?</td><td>Specify time period (list years):

Specify number of time points:___</td><td>Other, please explain:</td></tr>
<tr><td>21</td><td>Time Allocation for trend analysis (specify years/time period)</td><td colspan="2">□ First survey versus last survey _____
□ Predefined time points_____
□ All time periods _____
□ Other, specify</td></tr>
<tr><td>22</td><td>Methodology used to estimate change/trends. (Please describe & write formula and indicate page of article where this information is found).</td><td colspan="2">□ Paper only provided description of change (no quantification).
□ Decomposition, pg #_____.

<table><tr><td>□ Absolute chg</td><td>□ Relative chg</td><td>□ Regression</td></tr><tr><td>□ Percentage chg</td><td>□ Annual rate of chg</td><td>□ Other</td></tr></table>
Provide details on the methodology here:</td></tr>
<tr><td>23</td><td>Significance Testing?</td><td colspan="2">□ Yes, specify if known:_____
□ No</td></tr>
<tr><td>24</td><td>Important research findings. (Please indicate page of article where this information is found).</td><td colspan="2"></td></tr>
<tr><td>25</td><td>Please provide any other information or comments.</td><td colspan="2"></td></tr>
<tr><td>26</td><td>Please review the reference list and identify any references relevant to this systematic review.</td><td colspan="2">Enter the reference numbers here or the authors names (if references are not numbered).</td></tr>
</table>

Appendix 8: Summary of Results (Contraceptive Prevalence Rate)

	Author	Publication year	Country	Number of coverage measurements	Time allocation	Method for computing change
1	Abigail[148]	2010	Australia	10	Survey to survey	Regression analysis
2	Abma[149]	2001	United States	2	First and last surveys	Absolute change
3	Abma[150]	2004	United States	3	First and last surveys	Absolute change
4	Ali[151]	2003	Colombia & Peru	3	Survey to survey	Regression analysis
5	Anderson[152]	2006	United States	7	Survey to survey	Regression analysis
6	Anderson[153]	2003	United States	6	Survey to survey	Regression analysis
7	Bankole[154]	1999	United States	2	Survey to survey	Absolute change
8	Bertrand[155]	2001	Guatemala	4	First and last surveys	Absolute change
9	Blanc[156]	2009	Multinational	20	First and last surveys	Average annual rate
10	Bongaarts[157]	2006	Multinational	5	Survey to survey	Average annual rate
11	Carlson[158]	2001	Bulgaria	2	First and last surveys	Percentage Change
12	Carrasco-Garrido[159]	2010	Multinational	2	First and last surveys	Absolute change
13	Castro[160]	1994	Multinational	2	First and last surveys	Absolute change
14	Cleland[161]	2006	Multinational	10	median time points	Absolute change Average annual rate
15	Cleland[162]	2006	Multinational	9	First and last surveys	Absolute change
16	Cleland[163]	2011	Multinational	13	Median time points	Absolute change Average annual rate
17	Eltigani[164]	2009	Egypt & Tunisia	5	First and last surveys	Relative change
18	Evans[165]	1995	United Kingdom	3	First and last surveys	Absolute change
19	Falah-Hassani[166]	2009	Finland	6	Predefined time points	Absolute change

	Author	Publication year	Country	Number of coverage measurements	Time allocation	Method for computing change
20	Feyisetan[167]	2000	Multinational	2	Survey to survey	Absolute change
21	Fleissig[168]	1991	United Kingdom	2	First and last surveys	Absolute change
22	Gupta[169]	1999	Brazil	3	Survey to survey	Absolute change
23	Hassani[170]	2006	Finland	7	Predefined time points	Absolute change Relative change
24	Johnson[171]	1996	Multinational	18	Survey to survey	Absolute change
25	Khan[172]	2011	Bangladesh	5	Survey to survey	Absolute change
26	Khawaja[173]	2009	Palestine	3	Survey to survey	Absolute change
27	Kocourka[174]	2011	Czech Republic	4	Predefined time points	Absolute change
28	Lete[175]	2007	Spain	4	First and last surveys	Absolute change
29	Lucke[176]	2009	Australia	4	Predefined time points	Absolute change
30	Lutalo[177]	2000	Uganda	2	First and last surveys	Absolute change Relative change
31	Magadi[178]	2003	Kenya	3	First and last surveys	Absolute change Relative change
32	Martin[179]	2000	Canada	2	First and last surveys	Absolute change
33	Mburugu[180]	1991	Kenya	4	Survey to survey	Absolute change Relative change
34	Mohanty[181]	2009	India	3	Survey to survey	Absolute change
35	Mosher[182]	2010	United States	3	Survey to survey	Absolute change
36	Mosher[183]	2004	United States	3	Survey to survey	Absolute change
37	Mosher[184]	1990	United States	2	First and last surveys	Absolute change
38	Mosher[185]	1991	United States	2	First and last surveys	Absolute change
39	Njogu[186]	1991	Kenya	2	First and last surveys	Absolute change Relative change

	Author	Publication year	Country	Number of coverage measurements	Time allocation	Method for computing change
40	Pazol[187]	2011	United States	8	First and last surveys	Absolute change
41	Perlman[188]	2009	Russia	8	First and last surveys	Absolute change
42	Piccinino[189]	1998	United States	3	Predefined time points	Absolute change
43	Potter[190]	2009	United States	2	First and last surveys	Absolute change
44	Santelli[191]	2006	United States	2	First and last surveys	Absolute change
45	Santelli[192]	2000	United States	4	Survey to survey	Absolute change
46	Santelli[193]	2007	United States	2	First and last surveys	Absolute change
47	Seiber[194]	2007	Multinational	5	First and last surveys	Absolute change Average annual rate
48	Serbanescu[195]	2010	Georgia Republic	2	First and last surveys	Percentage change
49	Shah[196]	2001	Kuwait	4	First and last surveys	Absolute change Relative change
50	Toulemon[197]	1998	France	3	Survey to survey	Absolute change
51	Unspecified[198]	1999	Canada	4	Survey to survey	Absolute change

Appendix 9: Summary of Results (Child Immunizations)

	Author	Publication year	Country	Number of coverage measurements	Time allocation	Method for computing change
1	Anjum[199]	2004	Pakistan	2	First and last surveys	Absolute change
2	Bahri[200]	2003	Tunisia	14	Predefined time points	Absolute change
3	Barker[201]	2001	United States	2	First and last surveys	Absolute change
4	Bond[202]	2002	Australia	2	First and last surveys	Absolute change
5	Bonu[203]	2003	India	2	First and last surveys	Absolute change
6	Bosu[204]	2003	Ghana	11	First and last surveys	Absolute change
7	CDC[205]	2011	United States	2	First and last surveys	Absolute change
8	CDC[206]	2010	United States	2	First and last surveys	Absolute change
9	CDC[207]	2010	United States	2	First and last surveys	Absolute change
10	CDC[208]	2010	United States	2	First and last surveys	Absolute change
11	CDC[209]	2009	Multinational	2	First and last surveys	Absolute change
12	CDC[210]	2009	United States	2	First and last surveys	Absolute change
13	CDC[211]	2009	United States	2	First and last	Absolute change

	Author	Publication year	Country	Number of coverage measurements	Time allocation	Method for computing change
					surveys	
14	CDC[212]	2008	United States	2	First and last surveys	Absolute change
15	CDC[213]	2001	United States	2	First and last surveys	Absolute change
16	CDC[214]	1998	United States	2	First and last surveys	Absolute change
17	Chongsuvivatwong[215]	1993	Thailand	2	First and last surveys	Absolute change
18	Ciofi degli Atti[216]	2004	Italy	2	First and last surveys	Absolute change
19	Cutts[217]	1994	DRC	2	First and last surveys	Absolute change
20	Darling[218]	2005	United States	8	First and last surveys	Absolute change
21	Davila[219]	2008	United States	11	First and last surveys	Absolute change
22	Delamonica[220]	2005	Multinational	2	First and last surveys	Absolute change
23	Dyer[221]	1996	South Africa	2	First and last surveys	Absolute change
24	ElZein[222]	1998	Sudan	3	First and last surveys	Absolute change
25	Ewert[223]	1994	United States	3	First and last surveys	Absolute change
26	Fogarty[224]	2004	United States	3	First and last surveys	Absolute change

	Author	Publication year	Country	Number of coverage measurements	Time allocation	Method for computing change
27	Groom[225]	2007	United States	2	First and last surveys	Absolute change
28	Groom[226]	2006	United States	3	Predefined time points	Absolute change
29	Hawker[227]	2007	United Kingdom	7	Predefined time points	Absolute change
30	Kharbanda[228]	2010	United States	3	Predefined time points	Absolute change
31	Lang[229]	2011	Switzerland	2	First and last surveys	Absolute change
32	Langiano[230]	2005	Italy	2	First and last surveys	Absolute change
33	Lim[231]	2008	Multinational	11	First and last surveys	Average annual rate
34	Ma[232]	2011	China	10	First and last surveys	Absolute change
35	Main[233]	2001	Cambodia	2	First and last surveys	Absolute change
36	Mashal[234]	2007	Afghanistan	2	First and last surveys	Absolute change
37	McCauley[235]	2008	United States	6	First and last surveys	Absolute change
38	Morris[236]	2004	Honduras	2	First and last surveys	Absolute change
39	Ndiritu[237]	2006	Kenya	2	First and last surveys	Absolute change
40	Oliphant[238]	2010	Multinational	2	Predefined time	Absolute change

	Author	Publication year	Country	Number of coverage measurements	Time allocation	Method for computing change
					points	
41	Otten[239]	2003	Multinational	12	Predefined time points	Absolute change
48	Robinson[240]	2001	Indonesia	2	First and last surveys	Absolute change
42	Saad[241]	2009	Egypt	10	survey to survey	Absolute change
43	Salmaso[242]	1999	Italy	2	First and last surveys	Absolute change
44	Shimabukuro[243]	2007	United States	2	First and last surveys	Absolute change
46	Smith[244]	2011	United States	7	First and last surveys	Absolute change
45	Smith[245]	2009	United States	11	All time periods	Regression
47	Sokhey[246]	2001	India	2	First and last surveys	Absolute change
49	Stokley[247]	2011	United States	6	Predefined time points	Absolute change
50	Vernon[248]	1993	Zaire	2	First and last surveys	Absolute change
51	Vijayaraghavan[249]	2007	Kenya	2	First and last surveys	Absolute change
52	White[250]	1992	United Kingdom	2	First and last surveys	Absolute change
53	Yameogo[251]	2003	Burkina Faso	2	First and last surveys	Absolute change
54	Yusuf[252]	2001	United States	6	First and last surveys	Absolute change

	Author	Publication year	Country	Number of coverage measurements	Time allocation	Method for computing change
55	Zhao[253]	2010	United States	8	survey to survey	Absolute change
56	Zhao[254]	2009	United States	8	All time periods	Regression
57	Zimicki[255]	1994	Philippines	2	First and last surveys	Absolute change

Appendix 10: Summary of Results (Infant Feeding)

	Author	Publication year	Country	Number of coverage measurements	Time allocation	Method for computing change
1	Ahluwalia[256]	2003	United States	2	First and last surveys	Percentage change
2	Ahluwalia[257]	2000	United States	2	First and last surveys	Percentage change
3	Baker[258]	2006	Multinational	3	Survey to Survey	Absolute change
4	Banderali[259]	2003	Italy	2	First and last surveys	Absolute change
5	Besculides[260]	2005	United States	11	First and last surveys	Absolute change Relative change
6	Bonet[261]	2007	France	2	First and last surveys	Percentage change
7	Boschi-Pinto[262]	2009	Multinational	11	First and last surveys	Average Annual rate
8	Castro[263]	2009	Brazil	2	First and last surveys	Relative change Relative change
9	Chaparro[264]	2010	Multinational	2	First and last surveys	Percentage change
10	Elo[265]	1993	Peru	2	First and last surveys	Percentage change
11	Giovannini[266]	2003	Italy	2	First and last surveys	Absolute change
12	Grummer-Strawn[267]	1996	Multinational	2	First and last surveys	Absolute change
13	Hanif[268]	2011	Pakistan	2	First and last surveys	Absolute change
14	Hornbeak[269]	2010	Singapore	2	First and last surveys	Absolute change
15	Jacknowitz[270]	2007	United States	2	First and last surveys	Absolute change
16	Labbok[271]	2006	United States	2	First and last surveys	Absolute change
17	Leung[272]	2002	China	2	First and last surveys	Absolute change
18	Lutter[273]	2011	Multinational	2	First and last surveys	Compound annual growth rate

19	Michels[274]	2001	United States	2	First and last surveys	Absolute change
20	Parizoto[275]	2009	Brazil	2	First and last surveys	Absolute change
21	Quinn[276]	2005	Multinational	2	First and last surveys	Absolute change
22	Ryan[277]	2006	United States	2	First and last surveys	Absolute change
23	Ryan[278]	1991	United States	2	First and last surveys	Percentage change
24	Ryan[279]	1991	United States	2	First and last surveys	Absolute change Relative change
25	Venancio[280]	2010	Brazil	2	First and last surveys	Percentage change Absolute change
26	Zimmerman[281]	1999	United States	2	First and last surveys	Absolute change

Appendix 11: Metrics Used in the Measurement of Coverage Change for MNCH Interventions

(1) Average Annual Rate of Change (AAR)

The average annual rate of change is often calculated between two time points. It is a straightforward calculation of the difference between both rates divided by the amount of time between the coverage rates. This method yields the average change per year measured in percentage points. The ease of calculation and interpretability is an advantage of this approach, though given the sparsity of data points, we can comment only on general trends and may be ignoring monthly or yearly changes in patterns between our chosen data points.

(2) Linear Regression (LR)

The coverage rate is considered the outcome or dependent variable and year of coverage is the predictor or independent variable. The slope of the regression line is interpreted as the change in average coverage rate per year measured in percentage points. The main strength of this approach is that it considers all the values of the outcome variable in computing the average change in coverage per year. However a main limitation of this approach is the assumption of linearity of coverage trends over time. For instance, the country Congo has a U-shaped curve and using linear regression fits a straight line through the data and ignores the true shape of the trajectory over time. Plus, special methods are needed to calculate the uncertainty in the estimated

average change per year, since the data points are likely to be correlated.

(3) Absolute Change (AC)

Absolute change is the difference between two time points and it is measured in percentage points. This measurement is not an annual rate rather it summarizes the changes within any given time period. Only two time points are utilized therefore the underlying pattern of the data is ignored.

(4) Compound Annual Rate of Change (CAGR)

The compound annual rate of change is a multiplicative rate, i.e. it takes into account the changes that occurred in the previous year when calculating the rate of change in the next year. This rate of change is expressed as a percentage and it assumes a constant rate change per year. This method yields an annual change rate but it only uses two time points (the rates at the beginning and end of the time period) and ignores the pattern of the data within the two time points.

(5) Percentage Change (PC)

This is a summary measure of change between two coverage rates. The difference between the coverage rates is divided by the original rate and expressed as a percentage.

(6) Relative Change (RC)

The change in coverage is presented as the ratio of two coverage rates, using one rates as a reference i.e. the showing the number of times one rate is contained within the other rate.

Curriculum Vitae

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Education

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MPH, Biostatistics and Epidemiology
Certificate in International Health, June 2000

University of Massachusetts, Amherst, MA, December 1996
BSc, Microbiology

Employment

Jan. 2012 - Present
US Centers for Disease Control
Center for Global Health, Division of Global HIV/AIDS, Epidemiology and Strategic Information Branch
Epidemiologist-Clinical Monitoring and Evaluation

May 2009- Jan. 2012
Institute of International Programs, Johns Hopkins University School of Public Health, Baltimore, MD
Graduate Researcher

Apr. 2006- Aug. 2007
SAIC-Frederick, Inc.
Contractor to Tuberculosis Research Section, NIAID, National Institutes of Health, Bethesda, MD
Program Manager- Nigeria Project

Oct. 2003- Apr. 2006
Institute of Human Virology, University of Maryland, Baltimore, MD/ Penthouse Maina Court, Central District, Abuja, Nigeria.
Manager, Health Programs

Oct. 2002- Oct. 2003
Oak Ridge Institute for Science and Education Fellow, Navy Environmental Health Center, United States Navy, Portsmouth, VA
Epidemiologist Fellow

Feb. 2001- Apr. 2002	Ingenix, Epidemiology Division, Newton, MA *Research Associate*

Publications

Ajene AN, Fischer Walker CL, Black RE. "Enteric Pathogens and Reactive Arthritis: A Systematic Review of *Campylobacter*, *Salmonella* and *Shigella*-associated reactive arthritis." Journal of Health, Population and Nutrition. 2013 Sep;31(3):299-307.

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Charurat M, Datong P, Matawal B, Ajene A, Blattner W, Abimiku, A. "Timing and determinants of mother-to-child transmission of HIV in Nigeria." Int J Gynaecol Obstet. 2009 Jul;106(1):8-13.

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Riegodedios AJ, Ajene A, Malakooti MA, Gaydos JC, MacIntosh VH, Bohnker BK "Comparing diagnostic coding and laboratory results" Emerg Infect Dis. 2005 Jul;11(7):1151-3

A. Ajene, B. Bohnker, A. Riegodedios, M. Malakooti, Sack DM "Neoplasms in the Navy, 1998-2000: A Descriptive Analysis of the Physical Evaluation Board Database" Mil Med. 2004 Sep;169(9):707-11

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J. A. Cole, S. F. Cook, B. E. Sands, A. N. Ajene, et al., "Occurrence of colon ischemia in relation to irritable bowel syndrome" Am J Gastroenterol. 2004;99(3):486-91

J. E. Loughlin, T. D. Alfredson, A. N. Ajene, et al., "Risk of respiratory events in a retrospective cohort of patients receiving inhaled zanamivir" Clinical Therapeutics 2002;24(11): 1786-1799

J. A. Cole, J. E. Loughlin, A. N. Ajene, et al., " The Effect of Treatment on Influenza Complications: A retrospective cohort study" Clinical Therapeutics 2002;24(11): 1824-1839

K. Auger, A. Ajene, T. Lerner, "Progress toward the Cloning of CLN6, the Gene underlying a variant LINCL." Molecular Genetics and Metabolism 1999;66: 332-336

Awards and Fellowships

2010- 2011 Policy Fellow in Population Policy Communications
Population Reference Bureau, Washington, DC

2009 Recipient of the Robert D. and Helen S. Wright Award
Johns Hopkins Bloomberg School of Public Health

2008 Fogarty Research Fellow- Institute of Human Virology, University of Maryland, Baltimore, MD

2007- 2009 Recipient of the Diversity and Health Disparities Predoctoral Fellowship
Johns Hopkins Bloomberg School of Public Health

2002- 2003 ORISE Fellowship- Oak Ridge Institute for Science and Education
US Navy and Marine Corps Public Health Center, Portsmouth, VA